DEPARTMENT OF COMMERCE

U. S. COAST AND GEODETIC SURVEY

E. LESTER JONES, Superintendent

CENTENNIAL CELEBRATION

OF THE

UNITED STATES COAST AND GEODETIC SURVEY

APRIL 5 AND 6, 1916

WASHINGTON, D. C.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1916

CONTENTS

LIST OF ILLUSTRATIONS

CENTENNIAL CELEBRATION OF THE UNITED STATES COAST AND GEODETIC SURVEY

PREFACE

The commemoration of the one hundredth anniversary of the organization of the Coast Survey, celebrated in the city of Washington on April 5 and 6, 1916, is a memorial to the wise foresight of those early statesmen of our Republic who laid deep and well the foundations of a bureau which has done so much to establish the reputation of the country in the development of mathematical and physical science, and has made so ample a return for the support it has received from the Nation by safeguarding life and commerce on our coastal waters, and by making certain the means whereby are reproduced the public and private lines of proprietary subdivisions.

The celebration of the centennial included three public sessions devoted to appropriate addresses, held in the New National Museum; a banquet held in the New Willard Hotel, at which the invited speakers were the President of the United States, the Minister of Switzerland, the Secretaries of the Navy and of Commerce, and Doctor T. C. Mendenhall, former Superintendent of the Coast and Geodetic Survey; and included also an exhibit. The Superintendent presided at each of the three sessions and served as toastmaster at the banquet.

The exhibit, held in the New National Museum, was a comprehensive display of the various types of instruments used in the operations of the Survey, ranging from historic examples of apparatus designed and used by Hassler and Bache to the latest forms employed at the present day. Notable features were astronomical, geodetic, tidal, topographic, and hydrographic apparatus which owe their origin to the Survey and were constructed in its workshops.

The manifold experiences of the field parties of the Bureau under the various conditions encountered in the field of operations, extending from the Arctic Ocean to the southern limits of the Philippine Archipelago, were illustrated by prints from photographs made in the field.

The progress of the developments that has marked the improvements in surveying results between 1816 and 1916 was graphically shown by comparison of field sheets and by published charts from various periods.

The addresses delivered and herewith reproduced represent the judgment of representative leaders in the scientific, engineering, civic, and military life of the country upon the value of the operations and results of the first century of the Survey's existence. They contain inspiring forecasts of the results to be expected from its maintenance and development in accordance with the ever-increasing demands upon it incidental to the growth of the Nation and the ceaseless activities of nature.

AFTERNOON SESSION, APRIL 5, 1916

OPENING ADDRESS OF WELCOME BY THE SUPERINTENDENT

Mr. JONES: We are accustomed to express on every fit occasion our reverence for the virtue and patriotism in which the foundations of our country were laid, and to rejoice in blessings vouchsafed to us under our free institutions. To-day we have assembled to commemorate an event which happily illustrates the wisdom and enlightened forethought of those who designed our national structure, and worked out so wonderfully its many problems, past and present.

Our country was still young when President Jefferson recognized the need for securing definite knowledge of our coastal waters. Having conceived the idea, the plan was carried through (in spite of many difficulties) and the Coast Survey was established in 1816.

It is not my purpose to take any of our valuable time. It was James Russell Lowell who invented a new beatitude: "Blessed are they who have nothing to say, and can not be persuaded to say it." My few words are intended more as a pledge of my adherence to the cause than an attempt to say anything new or instructive.

But as in eloquent and fitting terms we shall be led, by those chosen to address us, to the contemplation of the history of this Bureau organized 100 years ago; as the lives and services of those who in the past have accomplished its fine work are rehearsed to us, I am sure we shall feel the inspiration and the just pride which ever comes from the contemplation of true patriotism and unselfish, well-directed labor.

The work of the Coast Survey is far-reaching and fills many other phases of the Government needs.

We have with us this afternoon one whom I feel is largely responsible for the recent great advancement in the work of the United States Coast and Geodetic Survey. His far-reaching constructive ideas, his broad vision and conception of both the practical and scientific, have given the Coast and Geodetic Survey the greatest stimulus in going forward in the past three years.

I take pleasure in introducing to you the Honorable William C. Redfield, Secretary of Commerce, who will say a few words of welcome to you.

ADDRESS OF HONORABLE WILLIAM C. REDFIELD, SECRETARY OF COMMERCE

Secretary REDFIELD: Mr. Superintendent, ladies and gentlemen, I realize fully that I am breaking in upon a program of far more interest than any contribution of mine can be. I did not intend to come here and make an address, though I would not have been willingly absent. I hoped to listen and do nothing more, and yet something is omitted from your program both for this afternoon and for to-morrow and to-morrow night about which a little something should here be said. So I am going to say it.

Long years ago—longer than I like to think now—we employed a commercial traveler. I remember him well. His name was McCarthy, a good Methodist, who used to say when they asked him to drink, in the days when drinking was common among commercial travelers, "Now, my friend, I promised my wife once I would not drink, and you would not like me to break my word to that lady, would you?" In that way he got around many an invitation to indulge. I remember saying to him once, "McCarthy, you get kind of lonesome off on the road, don't you, going way off thousands of miles from home? You do not hear, you do not know whether the concern is going on or not; you do not know whether the factory is burned; you do not know whether you are appreciated. You are all by yourself out in the big, big world. All you know is that you get your salary check; you do not get much else with it, just 'Please find inclosed the usual check.' Is it not kind of sad and lonely there, McCarthy?" He said, "It surely is, Mr. Redfield." I said, "McCarthy, we will break that up. Every Saturday night we will mail a letter to you, McCarthy; there may not be much in it, but if we can not say anything more we will just say, 'We hope you are well, McCarthy, and hope the work is right, and don't worry.'"

A year or two went by and he told me that he never realized what the touch of home—even though it was such a little touch as that—meant to him; that it gave him a sense of living unity with his work, a sense of human values.

I am going to talk to you about human values in the Coast and Geodetic Survey. It would not be worth much without human values. A dead scientific brain, however actuated by power, would be a pretty hopeless kind of thing. You could not sympathize with it. An automatic, scientific surveying apparatus would not enthuse us very much, but when men, our men, men whom we know, go out in the waste places of the world and very far from the haunts of active life they do better work because they are on their honor to do it. When they go out and apply to the deserts and the mountains the truths of science, when they annex the globe and make it plastic in the hands of man because of what they have done, when the human spirit overcomes nature, when the human heart and mind conquer difficulties—those are greater things than any arbitrary facts of mathematics or of science. Those are the bigger things. The men who do the work in the field or on the ships are bigger than the work they create; the creator is larger than the created. That is what I care supremely about. It is you, in your work, you who make the work, who are greater than the work, out of whose life the work comes, whose work is a witness to what you are. That is the thing of supreme value, and how sad it is, how very sad it is how little is thought of it.

Let us make a new rule as we commence the second century of this work, that this century shall be full of the science of human life, that the men in the field are not forgotten, that our thought goes out to them every day, wherever they are, and that the whole great widespread organism from the far Philippines to Porto Rico and from Alaska to the Caribbean Sea is all instinct with the life of a living thing. If we can make that our high ideal, our life will be sweeter and our work will be none the worse. In that spirit I welcome you most cordially here, and let us from this day breathe, if we may, a new spirit into our labors.

Mr. Jones: Our second address will be "The United States Bureau of Fisheries, and Its Relation to the United States Coast and Geodetic Survey." My interests in that bureau are twofold. First, I have had the privilege, which is always a pleasant thought, to have been associated with that important arm of the Government for two years, and I know much of its work; and, second, as Superintendent of the Coast and Geodetic Survey I realize that in past years we have contributed in a measure to the great work which that Bureau has carried on.

We have with us this afternoon its head, and I take pleasure in introducing to you Doctor Hugh M. Smith, Commissioner of Fisheries.

THE UNITED STATES BUREAU OF FISHERIES AND ITS RELATION TO THE UNITED STATES COAST AND GEODETIC SURVEY

Doctor Smith: Long before the Coast and Geodetic Survey and the Bureau of Fisheries were adopted by the same mother department and thus became sisters—in fact, as early as 1873, when the former had already attained a robust maturity and the latter was still in swaddling clothes—there began close cooperative relations. These have continued up to the present time and have increased in intimacy and value in more recent years since the two establishments became members of the same official family. It is only fair to acknowledge that at first the cooperation was very one-sided, consisting largely of the bestowal by the Coast and Geodetic Survey of substantial favors in return for profuse thanks. From 1880, when the Bureau of Fisheries began to acquire vessels of its own, that service began to repay, in part at least, some of its obligations, and ultimately it contributed substantially to the published records of the Survey. The former has always depended on the latter for its basic triangulation whenever a biological survey of any kind has been undertaken in a region in which the Coast and Geodetic Survey has operated, which, of course, means anywhere on the coast of the United States. On the other hand, the hydrographic and topographic results of this biological work have always been made available to the Survey.

On both the Atlantic and Pacific coasts some of the offshore soundings found on the charts were determined by the steamers *Fish Hawk* and *Albatross* in pursuance of their fishery investigations, and some of the inshore data of certain of the earlier charts came from reconnoissances by the *Albatross*. While much of the latter has been superseded by more accurate work, as the Coast and Geodetic Survey was able to extend its operations, it served a good purpose for some years. Later, there came into the command of these two vessels naval officers who had been trained in the Survey, with resulting improvement in the character and accuracy of the fishery surveys, not only those under their immediate direction but throughout the service. I can not let this opportunity pass without paying humble tribute to the distinguished labors in behalf of oceanic physics and biology performed by men like Z. L. Tanner and J. F. Moser, who, while retaining their naval status, commanded fishery vessels, and collected invaluable material for the Coast and Geodetic Survey.

The gathering of hydrographic and other data for use of the Coast and Geodetic Survey by the steamer *Albatross* has been extensive in the Pacific Ocean and along the west coast of America. The work began in 1888 and has continued to the present time. In addition to using the material thus obtained for perfecting its charts, the Survey has published two special bulletins dealing exclusively with the results of *Albatross* work in various parts of Alaska.

One of the interesting phases of this activity of a vessel in the fishery service in behalf the Survey has been the search for reported dangers to navigation that were inaccurately charted or possibly nonexistent. Thus, in 1890, the *Albatross* searched for Anderson Rock, off Sannak Island, Alaska, and disproved its existence in the location assigned. Again, in 1888 and 1892, it devoted considerable time to sounding in the Fairweather Ground off Cape St. Elias, Alaska, in an effort to locate the celebrated Pamplona Rock, first reported by the Spaniard Arteaga in 1779, referred to by Vancouver and other early navigators, carried on American, British, and other charts for many years, and listed as a very dangerous though uncertain reef in various coast pilots and maritime directories. Coast Survey chart No. 8500, which is "compiled from British and Russian authorities by the United States Coast and Geodetic Survey and the United States Fish Commission," published in 1900 and corrected to 1904, very properly omits Pamplona Rock and gives the *Albatross* soundings over the ascribed location of this reef, for it has become evident that if it ever existed it is now submerged to a depth of 1,500 to 1,750 fathoms, making it no longer a menace, even to submarine navigation.

It is impracticable to enumerate the various kinds of public service which the two bureaus have undertaken together and carried to successful completion, and the few minutes of my time remaining will be devoted to a reference to what I conceive to be the chief cooperation in which they have engaged. This has been in behalf of the most important, most valuable, most abused, and most neglected of all the inhabitants of our waters. I refer, of course, to the peerless American oyster.

It would be a highly commendatory act for anyone to make two oysters grow where only one grew before. How much more praiseworthy has been the cooperative effort which has made millions of bushels grow where none grew before!

The first work on the oyster grounds was done by the Coast and Geodetic Survey in Georgia, North Carolina, and Chesapeake Bay between about 1880 and 1891. Later it was recognized that such work is primarily biological, that engineering operations are mainly to provide the skeleton on which to erect the biological and economic facts the determination of which is the main purpose in view; and thereafter the oyster surveys were conducted by the Bureau of Fisheries.

At first the old triangulation points of the Coast and Geodetic Survey were depended on to supply the necessary framework, but later the cooperation was more explicit and in many cases the Survey performed special triangulation while the Bureau of Fisheries did the hydrographic and biological work, which parts can not be separated. The results of this cooperation have been advantageous to both parties to it. The Bureau of Fisheries was provided with fundamental data more accurate than it was able to provide for itself, and the Coast and Geodetic Survey not only reestablished triangulation in regions in which the original physical marks were lost, destroyed, or otherwise deficient, but it obtained from the Bureau of Fisheries hydrographic and topographic data for the correction of charts which the changes wrought by time had made inaccurate. These changes are particularly likely to occur in oyster regions, especially on the southern coasts, owing partly to the upbuilding or destruction of the beds and partly to geophysical conditions which cause some inlets to close, others to open, and all to fluctuate more or less in position and surroundings.

In conclusion reference may be made to the most extensive, long-continued, and important work which the Coast and Geodetic Survey and the Bureau of Fisheries have undertaken jointly. This was in behalf of the oyster industry of Maryland, a State whose natural oyster resources, not equaled elsewhere, have for many decades been dealt with in a most inefficient manner and have paid the penalty arising from gross neglect.

In 1906, at the request of the State of Maryland, expressed by the legislature and preferred through the governor, and by authority of an act of Congress carrying an appropriation, the bureaus began cooperation with the Maryland Shell Fish Commission in the survey of the natural oyster beds of that State. The work was prosecuted assiduously and was not concluded until 1913, after an expenditure of $125,000 by the State and $75,000 from the Federal Treasury.

This survey was predicated on the passage by the Legislature of Maryland of a fairly adequate law for the encouragement of oyster culture and on the belief that this legislation would not be weakened and presumably would be perfected in the course of time. Very soon after the conclusion of this survey the legislature passed a law which made it practically useless. Lessees who had entered on oyster culture in good faith were threatened with dispossession, and condemnation proceedings were brought; but in view of the vested rights of the lessees, damages were awarded against the State to the amount of about $300,000 in one county alone. As the State treasury was already in a condition of incipient bankruptcy, there was no money available for the payment of the damages and the judgments obtained could not be given effect. The whole situation was thrown into confusion, the oyster planters did not feel warranted in proceeding under the threat of possible dispossession, and the State could not take possession of the leaseholds and throw them open to the common fishery.

There the matter rests, but it seems probable that some good must come from all the agitation; and there is reason for hope that an aroused public sentiment, especially in parts of the State away from the tidewater, may prevent Maryland from lapsing into another protracted comatose condition while her wide-awake sister States are reaping the golden harvest that inevitably comes to those who intelligently plant the waters; and that its costly lessons of the past, the dictates of common sense, the advice of every disinterested, competent authority may lead her to accord just treatment to her most valuable natural asset, and thus to show her appreciation of the cooperative work in her behalf performed by two bureaus of the Federal Government such as has never been equaled in magnitude and thoroughness in behalf of any other State.

Mr. Jones: The next address will be "The Work Done by the United States Coast and Geodetic Survey in the Field of Terrestrial Magnetism," and will be delivered by one who is especially qualified to speak on the subject.

As a computer in the Bureau from 1887 to 1892 he became impressed with the importance of that field of investigation and recognized the very small part that the United States had been able to take up to that time in advancing our knowledge of the earth's magnetism.

As chief of the division of terrestrial magnetism and inspector of magnetic work in the Survey from 1899 to 1906, he was in a large measure responsible for the successful expansion of the work, which became possible in 1900.

As director of the department of terrestrial magnetism of the Carnegie Institution of Washington since 1904, he has had opportunity to compare the work of this Bureau with that of similar organizations in other countries. I take pleasure in presenting Doctor Louis A. Bauer.

THE WORK DONE BY THE UNITED STATES COAST AND GEODETIC SURVEY IN THE FIELD OF TERRESTRIAL MAGNETISM

Doctor BAUER: Professor Alexander Dallas Bache, the second Superintendent of the Coast Survey, and Doctor J. E. Hilgard, the fifth incumbent of this honored office, contributed a joint paper to the Coast Survey report for 1856, which also appeared in the July, 1857, number of the American Journal of Science and Arts. The paper bore the title "On the General Distribution of Terrestrial Magnetism in the United States, from Observations Made by the United States Coast Survey and Others." The opening sentences read as follows:

> During the progress of the Coast Survey within the last 12 years, observations of the magnetic elements have been made, under special instructions from the Superintendent, at most of the astronomical stations, and near many capes and harbors where a knowledge of the variation of the compass was requisite for the use of navigation. The number of magnetic stations now amounts to about 160, distributed (irregularly as yet) along the entire sea coast of the United States, on a great portion of which magnetic observations were now made for the first time.

That was the status of the magnetic work of the Coast Survey six decades ago. At the close of 1915 the stations at which the magnetic elements have been completely determined by the Survey number, in the United States proper, about 5,000 and in the outlying possessions, about 500. They are now found to be more regularly distributed. About 80 per cent of the stations have been occupied during the period 1899 to 1915 and at about 10 per cent the observations have been repeated from time to time in order to determine the changes ever going on in the earth's magnetism. In addition, magnetic data at sea have been accumulated, as opportunity afforded, on cruises of Coast and Geodetic Survey vessels; a number of magnetic observatories (five at present), where the countless fluctuations of the earth's magnetism are being continuously recorded, have been operated; invaluable compilations of all available magnetic data in the United States and contiguous countries have been made; the instruments used have been improved from time to time; and about 150 magnetic publications and a large number of magnetic charts of various kinds have been issued, nearly one-third of the publications having appeared during the last 16 years. The Survey likewise has rendered effective aid to various persons and expeditions in the loan of magnetic instruments, training of observers, and preparation of instructions, and has cooperated in special international magnetic observations.[1] So without fear of contradiction it may be said that the contributions of the Coast and Geodetic Survey to the advancement of our knowledge in terrestrial magnetism have been unexcelled by any other national organization.

---

[1] To serve the interests of the surveyor when he has occasion to use the compass in his surveys, the Coast and Geodetic Survey has also established at many county seats throughout the country meridian lines for the testing of compasses.

It were a fortunate fact, indeed, had other countries emulated the example of this organization and had preserved and put in accessible form all past data having a bearing on the changes in the compass direction and on the other magnetic elements. Thanks to the compilations of such data, made chiefly during the period when the late Charles A. Schott was chief of the computing division, this Survey has been able to furnish with promptness invaluable information in the adjudication of disputed land boundaries, the bearings of which were referred to the compass direction when originally laid out, 100 to 150 years ago or more.

From the earliest days of the Survey magnetic observations were considered a legitimate and useful part of its work. In the "Plan for the Reorganization of the Survey of the Coast," as adopted in 1843, there was explicit provision for the making of "all such magnetic observations as circumstances and the state of the annual appropriations may allow." Since then Congress, by annual appropriations, has continuously and increasingly recognized the importance of this feature of the work of the Survey, so that in 1899 an enlarged annual appropriation of $25,000 (about ten times the average annual amount previously allotted) made it possible to carry out a magnetic survey of the whole United States on a more systematic basis and with greater expedition than had theretofore been possible.

The plan adopted for the reorganized magnetic work of the Survey, on the basis of which the increased appropriation was requested, was that submitted by me at the request of Superintendent Pritchett.[1] I was at the time on the faculty of the University of Cincinnati, but had been connected previously with the Survey as a member of the computing division under Mr. Schott, from 1887 to 1892. I had also been in charge of the detailed magnetic survey of Maryland from 1896 to 1899, which was conducted under the auspices of the Maryland Geological Survey (William Bullock Clark, director), with instruments loaned to the State of Maryland by the Coast and Geodetic Survey.

The example set by Maryland was soon followed by North Carolina, and it appeared to Superintendent Pritchett that the time was ripe for organizing a magnetic survey of our entire country along the general lines of the Maryland magnetic survey. Doctor Pritchett having received the necessary authority to proceed, and I having been fortunate in passing successfully the civil-service examination as an "expert in terrestrial magnetism" (there being no competitors), a new division, known as the division of terrestrial magnetism, was established on May 1, 1899, and put under my charge. To this division there were added:

[1] The plan contemplated observations of the three magnetic elements at stations which at first were to be about 30 to 40 miles apart; next, additional stations in magnetically disturbed areas; repeat observations at a suitable number of stations for the control of the secular changes of the magnetic elements; and the operation of a certain number of magnetic observatories at fixed stations. See Appendix 10, Report of the Coast and Geodetic Survey for 1898–99. This appendix also contains an account of the magnetic work and magnetic charts previous to 1899.

Assistant J. B. Baylor, who for many years had made magnetic observations under Schott's direction; Computer D. L. Hazard, previously a member of the computing division under Mr. Schott and at present chief of the division; and Messrs. J. A. Fleming and H. W. Vehrenkamp, two of my students at the University of Cincinnati, who having passed the civil-service examination were appointed aids and attached to the new division. They were immediately trained by me in field work, and thus both the field operations and the computing work of the division were fairly well organized when the increased annual allotment of $25,000 became available on July 1, 1899. With the later addition of magnetic observers, among the first of whom was W. F. Wallis, who for a decade served the Survey faithfully, the work in the field and office could then be energetically prosecuted. The chief of the division was also appointed at this time inspector of magnetic work.

During the period 1900 to 1903, five magnetic observatories were established and put in operation, in connection with which effective and skillful assistance was rendered by J. A. Fleming. Special buildings were erected for the observatories at Cheltenham, Maryland; Sitka, Alaska; and Ewa, near Honolulu, Hawaii, in accordance with plans [1] based on a careful study of existing magnetic observatories. Similar buildings were likewise constructed later at Vieques, Porto Rico, to replace the temporary quarters used there at first. Also when the provisional observatory at Baldwin, Kansas, at which the observations had begun in 1900, was abandoned, special buildings for the new observatory at Tucson, Arizona, were erected in 1909. The buildings at Vieques and Tucson were designed by Observer W. B. Keeling, who had charge of the construction of the former and was preparing for the erection of the latter when he met with the accident which caused his death.

Besides fulfilling the needs of a magnetic survey of our country, the five magnetic observatories of the Coast and Geodetic Survey were established in time to cooperate successfully with the British and German Antarctic expeditions of 1902 to 1903. The care evinced in the selection of the sites for these observatories has had its reward in the circumstance that, thus far, in no instance have the observations been vitiated by the disturbing influences of electric car lines or industrial establishments. In addition to magnetic instruments, there are installed at the magnetic observatories of the Coast and Geodetic Survey seismographs for the continuous recording of earthquake tremors. Thus, the most comprehensive records, in the United States and possessions, for the California earthquake of April 18, 1906, were contributed by the Survey, for at that time but very few seismographs had been installed in our country.

The year 1903 is memorable in the progress of the Survey's magnetic work, for it marks the inauguration of systematic magnetic observations

[1] See Appendix 5, Report of the Coast and Geodetic Survey for 1902.

at sea on the Survey vessels. During a trip made by the writer as inspector of magnetic work from Baltimore to Porto Rico on the *Blake*, then in command of Assistant R. L. Faris, the present Assistant Superintendent, magnetic observations, comprising the magnetic declination, the dip, and the intensity of the magnetic force, were made daily at sea with the aid of newly installed instrumental appliances. Mr. Faris and I vied with each other as to speed and accuracy in these observations. I recall with much pleasure our joint gratification at being able, on the conclusion of the trip, January 27, 1903, to cable Superintendent Tittmann: "Marine magnetics successful; daily observations." This experience, as well as that later obtained in the conduct of the work, assisted me in no small measure in the inauguration of the magnetic survey of all the oceans under the auspices of the Carnegie Institution of Washington. And in this connection it should be recorded that the first cruise of the Carnegie Institution vessel, then the *Galilee*, was made under the command of Assistant J. F. Pratt, who had received from the Coast and Geodetic Survey a furlough of six months in order that he might assist me in the inauguration of this new work. The cruise was made during the period July to December, 1905, in the Pacific Ocean from San Francisco to San Diego, thence to Honolulu and Fanning Island, and return to San Diego. On this cruise there were, furthermore, as watch officer and observer, Paul C. Whitney, and as surgeon and observer, Doctor J. Hobart Egbert, both of whom were likewise given furloughs by the Coast and Geodetic Survey. Since then there has been effective and cordial cooperation in magnetic work between the Coast and Geodetic Survey and the department of terrestrial magnetism of the Carnegie Institution of Washington. The latter organization, in return for the assistance received from the former, has repeatedly supplied, for example, magnetic data obtained in contiguous countries to the United States and on the adjacent oceans.

One of the warmest supporters of the project of a world magnetic survey, as submitted by the writer to the Carnegie Institution, was Doctor Tittmann. During the period 1904 to 1906, by special permission received from the Secretary of the Department of Commerce, I devoted my time about half and half between the magnetic work of the Coast and Geodetic Survey and that of the Carnegie Institution. During this period, however, the requisite preparations were made to insure the uninterrupted progress of the magnetic work of the Survey when it became necessary for me, on September 1, 1906, to devote my entire time to the department of terrestrial magnetism of the Carnegie Institution of Washington.

A review of the magnetic work accomplished by the Survey during the period 1906 to 1915 gives ample evidence that the work was carried out successfully under the charge of my successor, R. L. Faris, who was ably assisted, as I had been, by the chief computer of the division of terrestrial magnetism, D. L. Hazard. It is especially gratifying to note the continued promptness in the publication of the acquired magnetic data. It is hoped that the Survey will continue to set the example in this respect to other institutions engaged in magnetic work.

These introductory remarks must suffice as regards a general account of the work done by the United States Coast and Geodetic Survey in the field of terrestrial magnetism. Time will not permit going into greater detail. Let me instead single out one particular line of inquiry in which the magnetic work of the Survey has been preeminent—the study of the secular changes of the magnetic elements, more particularly of the magnetic declination (variation of the compass).

Figure 1 gives "Typical curves showing the secular variation of the magnetic declination in England and North America from the dates of the earliest observations." Looking first at the London curve, it would appear that near the year 1580 the compass pointed about 11° east; there are indications that prior to 1580 the easterly bearing of the north end of the compass was less than this amount. After 1580 this easterly bearing began to diminish until about 1658, when it was zero, or the compass needle stood exactly north and south. Thereafter the north end of the compass needle pointed west by an ever increasing amount, until about 1812, when the westerly bearing was somewhat over 24°. Since 1812 the amount of the magnetic declination at London has been steadily decreasing, until it is now about 15° west. We thus see that the compass bearing at London from 1580 to 1812, or during an interval of 232 years, changed from 11° east to 24° west, or 35°. While the average rate of change was 9 minutes per year, as a matter of fact, the annual change was not uniform but varied from 0 to about 14 minutes of arc.

Until quite recent times it was thought that the secular variation ran through a regular, rhythmic course, and it was often likened to the swing of a pendulum. After a certain period of years it was supposed that the compass bearing would pass through the same cycle of changes as it had previously. Judged from the London curve, for example, it was assumed that the secular variation period might be approximately twice the interval of years which had elapsed between the easterly extreme in 1580 and the westerly extreme in 1812, hence about 450 to 500 years.

However, the extensive data collected by the Coast and Geodetic Survey gradually began to show that the time interval between observed easterly and westerly extremes is shorter in North America than in Europe. Thus, turning to figure 1 we find that for St. John's, Newfoundland, the interval was about 180 years; for Trenton, New Jersey, it was 130 years; and at Houston, Texas, it was but 50 years. Hence, the secular variation period, if it is to be regarded as twice the interval of time elapsed between two extreme positions of the compass direction, would vary apparently from about 500 years in western Europe to 100 years and less in the western part of our country.

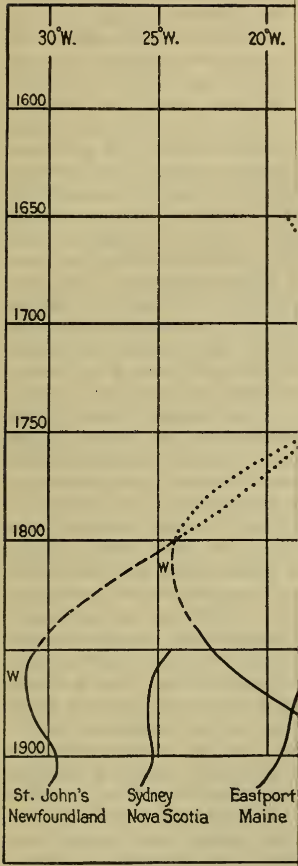

FIG. 1.—TYPICAL CURVES SHOWING TH

44282°—16. (To face page 18.)

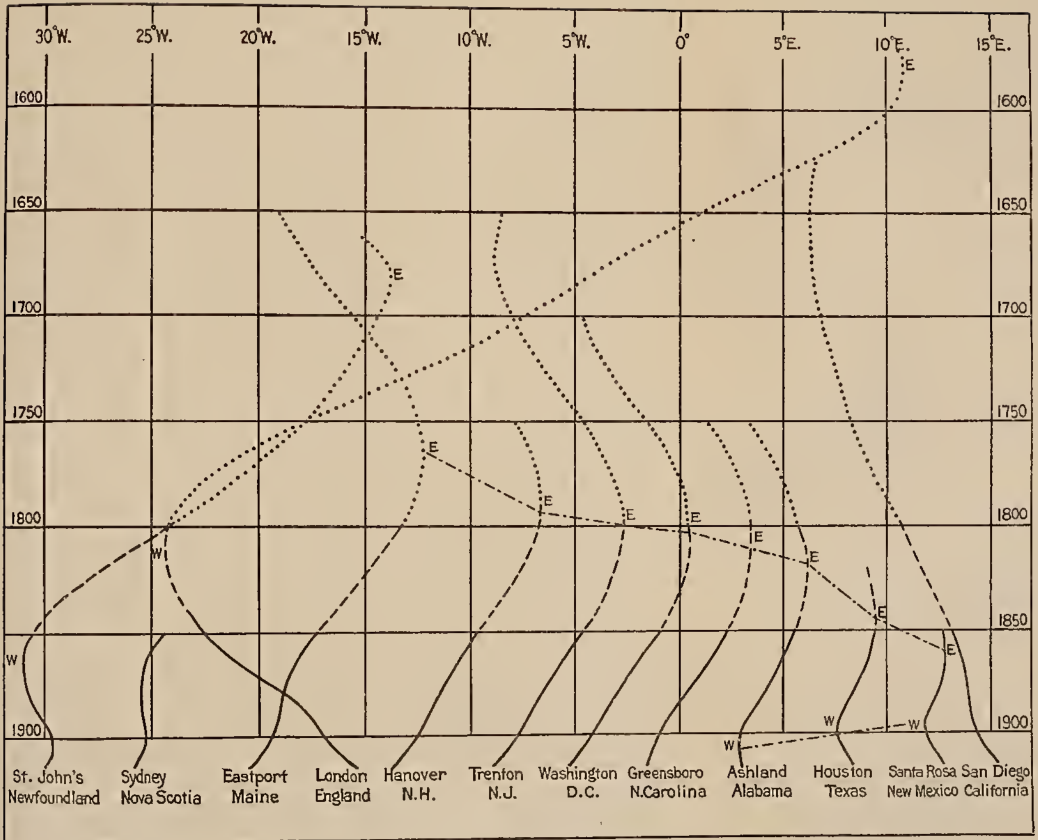

FIG. 1.—TYPICAL CURVES SHOWING THE SECULAR VARIATION OF THE MAGNETIC DECLINATION IN ENGLAND AND NORTH AMERICA FROM THE DATES OF THE EARLIEST OBSERVATIONS

44282°—16. (To face page 18.)

By following the progression of certain salient characteristics of the secular variation across the United States (see fig. 1), it will be observed how this apparent shortening of the secular variation period occurs. Let us follow first the progress of the easterly extreme of the compass direction, marked by the letter E for the various curves. We see that starting with London and going across the Atlantic to St. John's, Newfoundland, and thence across the United States, this phase has apparently occurred later and later. The march across the Atlantic from London to St. John's took approximately from 1580 to 1685, or about 105 years, which implies a motion of half a degree in longitude per year. For the phase E to pass from St. John's to Eastport, Maine, took approximately from 1685 to 1765, or about 80 years, the average motion in longitude being 0.2° per year. From the stations in the United States alone, we find that the annual motion in longitude of this easterly phase was 0.48°. The average annual motion in longitude between London and the west coast of the United States, or one-third of the way around the earth, was about 0.4°. If this rate of motion continues completely around the earth, then after the lapse of about 900 years from the year 1580—that is, about 2480—the easterly phase will have returned to London. This is, in fact, about the length of one of the periods postulated by past investigators, as, for example, Lord Kelvin. Examination shows, however, that the westerly rate of motion differs considerably for various parallels of latitude. Periods of the secular change, deduced in this manner, vary from several hundred years to several thousand years.

Let us next try to follow in the same manner as before the progression from station to station of the westerly phase, W. At London this phase occurred about 1812 and at St. John's, Newfoundland, about 1865; hence, the annual motion in longitude was about 1°, or twice as rapid as was the progress of the easterly phase across the Atlantic. Inspecting next the Sydney curve (fig. 1), it would appear that the westerly extreme which occurred about 1880 was evidently not the final extreme; a secondary wave seems to have made its appearance, causing a minor easterly extreme about 1900 and thereafter a westerly march of the compass direction again. At Eastport the westerly phase had not occurred as late as 1915. Crossing the United States we do not find any curves (see fig. 1) with westerly extremes until Ashland, Alabama, is reached. In fact, it would appear that this phase occurred earlier in the Western than in the Central States and that it has not yet taken place in the Eastern States. In brief, it would seem that there is a westerly phase moving eastward from the Pacific Coast States (see fig. 1, progression of W, right-hand side) at an average annual rate of motion in longitude of about 1°.7, or about three to four times as fast as was the progress of the easterly phase E westward. Hence, if the westerly phase traveled around the earth at this same average rate, it would make a complete circuit in 300 years or less.

It is seen, then, that the time interval between two extreme positions of the compass direction is a very complicated matter—the interval may be two centuries or more, as shown by the London curve, or it may be but 20 years, as indicated, for example, by observations in Arizona. The length of the interval at any station depends entirely upon its position with reference to the various secular-variation waves sweeping over the earth or portions thereof, apparently both in an easterly and in a westerly direction.

These curves (fig. 1) will also serve to show that it is no longer worth while to go to the labor of establishing mathematical formulæ to represent the changes of the magnetic declination at any one station. The predicted values derived from such formulæ, even for so short a space of time as 5 or 10 years, have proved to be erroneous by 0°.5 or more, thus vitiating their use for even the practical purposes of surveying. Accordingly there was introduced instead in the Survey a decade ago the method of graphs or curves to represent the observed changes of the magnetic declination. From these graphs are scaled the values of the magnetic declination for intervals of five years at a sufficient number of stations, usually one to three for each State, according to its area. These scaled values serve to furnish finally the declination changes supplied by the Survey in answer to calls from surveyors or others.

Another advantage of these graphs is that they tend to preserve the countless short-period fluctuations, instead of tending to eliminate them, as do the empirical, mathematical formulæ, which necessarily are based on more or less preconceived notions as to how the secular changes should progress. In other words, while at times, owing to uncertainty of data, even the graphs require smoothing out, nevertheless in general they are fairly true representations of the actual facts, rather than counterfeits of them as computed results are often found to be.

This experience as to the uselessness of empirical formulæ for the purposes of prediction has been encountered not alone in terrestrial magnetism, but likewise in that supposedly far more exact science, astronomy. There are certain outstanding motions of members of our solar system which are proving exceedingly puzzling to the astronomer, defying, in fact, the most subtle mathematical applications of the gravitation theory for their adequate explanation.

The most baffling of these astronomical problems is that of accounting for the irregularities of the moon's motion, as exhibited by observations during the past two or three centuries. Noted astronomers who have made the investigation of the moon's irregularities the object of special study—such as Newcomb and Brown, for example—have had to reach the conclusion that it is futile to establish a mathematical formula. To quote from a recent article [1] by Doctor F. E. Ross, who, it will be recalled, was for many years in charge of the international lati-

[1] Astronomical Journal, No. 667, May 19, 1914, p. 156.

FIG. 2.—REPRODUCTION OF FIRST MAGNETIC DECLINATION CHART OF THE UNITED STATES

44282°—16. (To face page 20.)

tude station at Gaithersburg, Maryland: "The moon now appears to be at an epoch in its history in which it is hazardous to attempt to predict its position even two years in advance. Being less amenable to theory and mathematical formulation than has hitherto been supposed, light is shed on the discordant results obtained in the discussion of ancient and medieval eclipses."

It may be of interest to record here an incident which occurred at about the time when the writer was inaugurating the world magnetic survey under the auspices of the Carnegie Institution of Washington. One day he received a visit from the late lamented Professor Simon Newcomb, the closing years of whose life were mainly devoted to a revision of his lunar tables. After a few words as to the object of his visit, he spoke somewhat as follows: "I am unable to account for the irregularities of the movements of the moon by any gravitation-disturbing effects. Have you any record of changes in the earth's magnetic condition with which the outstanding motions of the moon might be correlated?" He also intimated that he was particularly interested in the variations of the earth's magnetism of short period rather than in the slowly progressive changes which, as we have seen, may require many centuries for their fulfillment.

Unfortunately at the time certain studies which I had begun were not far enough along to permit me to give Professor Newcomb what he specially desired. Since then these studies, based in a large measure on the magnetic-observatory data of the Coast and Geodetic Survey, have progessed sufficiently to show that concomitant investigations of fluctuations in the earth's magnetism and those of the astronomical irregularities, such as have been referred to, may prove exceedingly interesting, if not productive of the disclosure of a new set of forces which must be taken into account in astronomy of precision. It will lead us too far astray to go here into further details. Suffice it to say that the Coast and Geodetic Survey, by the uninterrupted continuation of its magnetic-survey work and its magnetic-observatory work, has presented to it an opportunity not to be despised to benefit mankind and enrich our knowledge in ways of which we may at present have but little inkling.

The magnetic survey of the United States receives added interest from the fact that it embraces nearly one-fifteenth of the land area of the globe—the largest land area for which a general magnetic survey on a homogeneous basis and with the requisite accuracy has at present been made. Furthermore, for no land area of similar size can the secular changes of the earth's magnetism be so comprehensively and so accurately investigated as for our country. This is in view of the circumstance that the magnetic survey of the United States has been going on with unbroken continuity for well-nigh three-quarters of a century and not at irregular intervals, as has been the case in other countries. Let us hope therefore that there never will be a cause for the cessation even temporarily of the activity of the Coast and Geodetic Survey in this important field of human inquiry.

Much still, however, remains to be done if the density of magnetic stations in the United States, or the number of points at which the magnetic elements have been determined for a given area, is to equal that of other countries. Thus, at the end of 1915, there had been established in the United States proper by the Coast and Geodetic Survey one station, on the average, for about every 600 square miles; that is, the magnetic observations were made at places about 25 miles apart. This is the *average* distance; for some Western States this distance is about twice as great. The magnetic survey of Holland averaged one station to every 40 square miles, that of Maryland one to every 95 square miles, and that of Great Britain one to every 139 square miles.[1]

A preliminary analysis of the magnetic conditions in the United States, which I made in 1907, indicated that when the magnetic stations in the United States have been established in sufficient number, facts will be disclosed of extreme interest and importance, not alone to the magnetician, but to the engineer, the geodesist, the geologist, and to the physiographer as well.[2]

A word as to the importance of the magnetic-observatory work of the United States Coast and Geodetic Survey. The purpose of a magnetic observatory is to obtain a continuous record, by photographic means, of the countless and continual fluctuations in the earth's magnetic state. Thus, for example, the compass direction at any given place in our country varies from morning to afternoon by an amount appreciable even in land surveying. Then, again, the compass direction may be modified in an instant, as the result of a so-called magnetic storm, by a degree and even, at times, by several degrees. There are many other magnetic fluctuations of which, however, we have no time to speak. The illustrations given will suffice to show the importance of the work of a magnetic observatory.

The first magnetic observatories established in North America were the one at Toronto in 1840 by the British Government and the one at Girard College, Philadelphia, in 1840, by Professor Bache. When three years later Professor Bache became Superintendent of the Coast Survey, he not only expanded the magnetic field work of the Survey, but also in 1860 established a magnetic observatory at Key West, Florida, which continued in operation six years. The photographic instruments were next transported to Madison, Wisconsin, and a series of continuous magnetic observations was obtained there from 1876 to 1880. Magnetic instruments were supplied to the two stations established by our Govern-

[1] Working under the plan for the general magnetic survey, published in the Coast and Geodetic Survey Report for 1898–99 (Appendix No. 10), there have been occupied on an average since 1899 about 250 new stations and 75 repeat stations annually, thus making the total number of stations about 325 per year.

[2] Science, N. S., vol. 27, pp. 812–816, May 22, 1908.

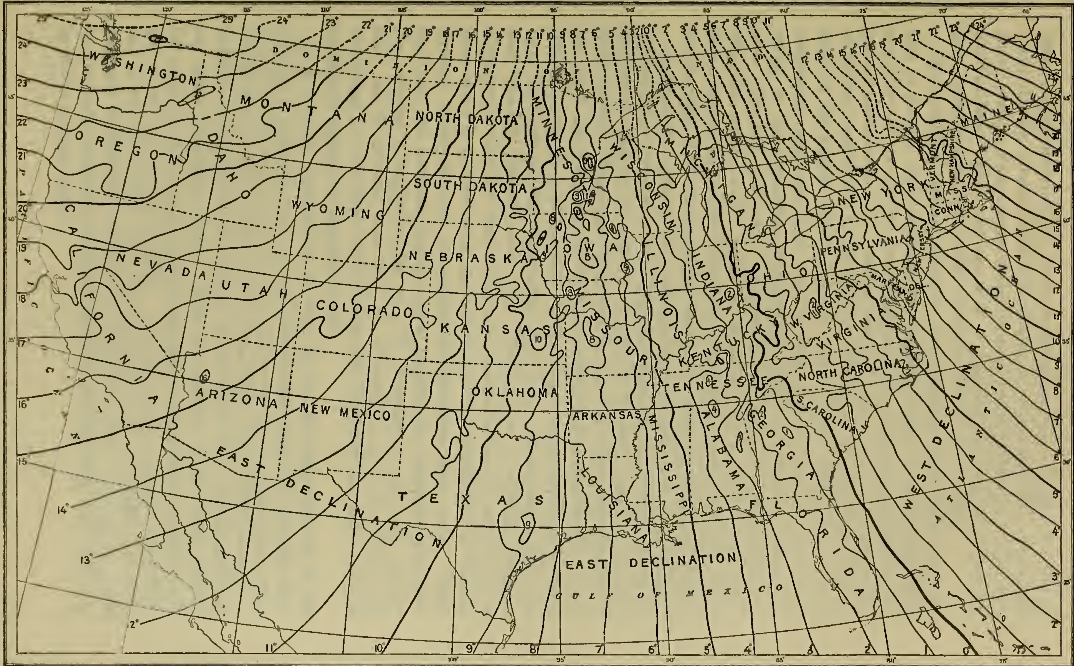

FIG. 3.—LATEST MAGNETIC DECLINATION CHART OF THE UNITED STATES, FOR THE YEAR 1915

44282°—16. (To face page 22.)

ment during the so-called international polar year of 1882 to 1883, at Point Barrow, Alaska, under the charge of Lieutenant Ray, and at the Arctic station, Fort Conger, under General Greely's direction. The Coast and Geodetic Survey also operated a magnetic observatory at Los Angeles, 1882 to 1889, and at San Antonio, Texas, 1890 to 1895.

This continual shifting, however, of a magnetic observatory from station to station, while necessary at the time, owing to the limited funds available and our limited knowledge as to the magnetic fluctuations, has proved unfortunate from various points of view. Canada has the credit of having maintained in the Western Hemisphere a magnetic observatory for the longest period of years. The Toronto observatory was in continuous operation from 1840 to 1897, when it had to be moved, owing to the disturbing influences of electric car lines, to Agincourt, some miles east of Toronto. The photographic series of observations at this new station began again in 1899 and has continued ever since. Thus, Canada enjoys the distinction of having a continuous record, save for one year, of the magnetic fluctuations for three-quarters of a century.

Fortunately, owing to the awakened interest and the increased annual appropriation granted by our Congress, beginning with 1899, it became possible to remedy the defects complained of with regard to our own observatories. There now have been in operation under the direction of the Coast and Geodetic Survey four magnetic observatories for a continuous period of 13 or 14 years. They are at Vieques (Porto Rico) since 1903, Cheltenham (Maryland) since 1901, Sitka (Alaska) since 1902, and near Honolulu (Hawaii) since 1902. Furthermore, at Baldwin (Kansas) a temporary magnetic observatory was maintained for the period 1900 to 1909, and a new, permanent observatory was then established at Tucson, Arizona, which has been in continuous operation since 1909. Thus, the Coast and Geodetic Survey has at present five magnetic observatories, ranging in longitude from 65°.4 W. (Vieques) to 158°.1 W. (Honolulu), and in latitude from 18°.1 N. (Vieques) to 57°.0 N. (Sitka) and embracing an area larger than is under the control of any other national institution engaged in magnetic work.

It is of great importance, in view of the universal approval of the activity in magnetic work of the United States Coast and Geodetic Survey, first, that its present five observatory stations be maintained uninterruptedly for many, many years, and, secondly, that additional observatories be established in the vicinity of the Canal Zone, and especially at our island possession, Guam. With the addition of the latter station, the magnetic observatories of the Coast and Geodetic Survey would extend almost halfway around the globe. Is it too much to hope for this extension of the observatory work, when we recall that it is through the earth's magnetic fluctuations—through its "magnetic pulse," so to speak—that we are made cognizant of mysterious forces the knowledge of which may be of the greatest value?

The total annual appropriation to cover all the incidental expenses of the magnetic-survey work and of the observatory work, including the cost of observatory buildings, instruments, general equipments, and also the salaries of 10 observers, is $25,000, or only about 2 per cent of the present total annual appropriation for all the varied operations of the Coast and Geodetic Survey. I believe that sufficient evidence has been presented in this paper to show that the 2 per cent is being well spent and that returns of great value are being obtained.

Could the annual funds for the magnetic work be increased by $5,000, it would be possible to establish and maintain the highly desired additional magnetic observatory at Guam. Could the increase be as much as $10,000, so as to make the annual budget for magnetic work $35,000, two additional magnetic observatories could be established and maintained, and provision be made for the steady and necessary promotion of the observers who are devoting themselves zealously and faithfully to the work. Were the annual amount $35,000, it would still be only about 3 per cent of the Survey's total annual appropriation for 1915.

In conclusion, let me emphasize the fact that all experience tends to show that instead of looking upon the establishment of a theory as the goal of an investigation, it should ever be regarded merely as a means to the goal, the advancement of buman knowledge. Theory after theory by the most eminent men of science has been proposed, from time to time, to account for the secular variation of the earth's magnetism. The facts at the time were so few as to fit the theory fairly well, so that the author felt tempted to make predictions. Usually he lived long enough to find them far afield. Not infrequently, however, an author had become so obsessed with his theory that, if observation did not agree with prediction, he believed that the former, of course, not the latter, was at fault. So eminent a physicist as James Clerk Maxwell uttered a warning against this too common tendency of mankind. In writing to Herbert Spencer on a subject of controversy in the latter's "First Principles," he said: "It is very seldom that any man who tries to form a system can prevent his system from forming around him and closing him in before he is 40. Hence, the wisdom of putting in some ingredient to check crystallization and keep the system in a colloidal condition."

Fortunately, if we do not allow ourselves to be blinded by misleading, empirical formulæ, nature will provide abundant ingredients to keep our systems in the desired colloidal condition. And these ingredients, as far as the subject of this paper is concerned, are those seemingly minor magnetic fluctuations, whose effects during the average span of human life are sufficient to upset the calculations of even the finest-spun theories. I for one regard these fluctuations as relatively more important than the larger ones whose full development none of us, even though he lived to the age of Methuselah, would probably see completed.

So let this be the message of this paper to the Superintendent of the Coast and Geodetic Survey, and to the chief of the division of terrestrial magnetism: Let your watchword ever be *continued, unceasing, and intelligent observation.* Having ever a clear object before you, keeping in mind always the demands of man and science alike, it is not improbable that you will continue to receive the same appreciative and generous support of our Congress as has been accorded the Survey in the past.

Mr. JONES: I am sure we are all very grateful to Doctor Bauer for showing us so clearly the great value of determining the variation in the compass, both to the mariner at sea and the surveyor on land.

Our next address will be "The Bureau of Standards and Its Relation to the United States Coast and Geodetic Survey."

The first Superintendent of the Coast Survey, Professor Hassler, realized from the beginning that it was necessary for conducting the work contemplated by the President and Congress to have accurate standards of measure in this country. He was farsighted enough to realize that it was also necessary for the scientific work which this country was doing or would have to undertake that there should also be standards of mass and volume.

During his four years' stay in Europe, while investigating geodetic and other surveying methods and instruments he procured standards of length, mass, and volume which he brought with him upon his return to the United States. This might be called the beginning of the work of the division of weights and measures of the Coast Survey.

From this division was created the Bureau of Standards, which is now one of the important scientific organizations of the Federal Government.

It gives me pleasure to introduce Doctor S. W. Stratton, the Director of the Bureau of Standards.

THE BUREAU OF STANDARDS AND ITS RELATION TO THE UNITED STATES COAST AND GEODETIC SURVEY

Doctor STRATTON: Mr. Superintendent, ladies, and gentlemen, there is so much that the Bureau of Standards owes to the Coast and Geodetic Survey that I fear in the time to which I am limited I can do no more than pay tribute in an humble way to some of the more important points.

Superintendent Jones has referred to the work of the first superintendent of the Coast and Geodetic Survey, F. R. Hassler. Those of you who have had an opportunity to look over the early legislation regarding weights and measures will find that the subject was recognized in the Articles of Federation and in the Constitution. Washington, in his first address, pointed out the necessity of making provision for standard weights and measures; he repeated this in the second and in the third addresses. Jefferson was ever mindful of this necessity and made reports upon it. John Quincy Adams made a report in 1821, which has become a classic in weights and measures literature.

Why was it that in all this time nothing had been done beyond the suggestions of legislatures and statesmen? There was something lacking—it was the man. Jefferson found the man, as shall be seen later. It is well known that Jefferson was very much interested in scientific matters and was acquainted with all of the scientific men of this country at that time.

When the man (Mr. Hassler) was found, he was at once sent to England to procure the necessary instruments for a coast survey. The first and most important instrument he secured was the standard of length, the basis of all the work to follow in the triangulation of the coast. He at the same time contracted for theodolites and other instruments to be used in conjunction with the standard of length.

Mr. Hassler was, indeed, a remarkable man. I consider that he was not only the first and foremost man in the scientific work of our country at that time but one of the leading, if not the leading, metrologists of his day. I doubt if there were more than half a dozen people in the world at that time who possessed the scientific knowledge and the deftness of the artisan necessary to undertake this work. He knew where to find the instruments; he knew where to find the artisans to construct the standards and apparatus that were necessary in the survey and in the weights and measures work. In addition, he had studied in the leading countries of Europe and had collected a wonderful library of books, a most unusual thing for one of that day. This will be referred to later.

As you of the Coast and Geodetic Survey know, when the set of instruments secured abroad by Mr. Hassler arrived, the coast survey work for the time being was abandoned. The instruments were stored. Mr. Hassler states that in the interval he assisted in fixing the northern boundary line of the United States, performed some duties at West Point, and sometimes refers to his farm up in New York, in which he, no doubt, took a great interest.

The real work in connection with weights and measures in this country began with the reorganization of the Coast Survey. Mr. Hassler was made its first superintendent. In this work he used the standards which he himself had brought to this country. It is remarkable that when he came to this country he brought with him one of the best standards of length of the day, upon which he later based the coast-survey work, not expecting, so far as I can learn, to have any connection with the scientific work of his adopted country.

At the reorganization of the Coast Survey, or very soon thereafter, the Senate by resolution directed the Secretary of the Treasury to examine the weights and measures of the customhouses. Up to this time the various customhouses had worked independently of each other; they used separate weights and measures from wherever they could be obtained—most of them came from England—and in some cases the customhouses depended upon the ordinary standards of the local officials.

Mr. Hassler's report of this duty is one of the most interesting documents I have ever read. It is as fascinating as any romance. It is, indeed, too bad that we have to look to his defenses for the real and interesting facts of this great work. Then, as now, auditors and accounting agents were always looking for discrepancies in the accounts of Government employees. Scientific men, then, as now, were strictly honest, and they thought that everybody ought to know it, and they naturally resented any questioning of their accounts. The most interesting part of this report consists of the replies that Mr. Hassler made to these alert employees of the disbursing and auditing offices, and I am going to quote from one or two of them merely because they give us some very interesting history, history that refers closely to the origin of our weights and measures.

When he was given the duty of examining these standards he might have contented himself merely by gathering together the standards of the customhouses, comparing them, and then adopting something that was uniform, but being a man of scientific attainments and a metrologist in the strict sense of the word, he foresaw that the commerce of the country would depend upon this work, that the weights and measures of the country would follow those of the Government, and that eventually we must come to uniform standards.

Now let us examine the history, the documentary evidence of the standards that he got together and compared, and I must pause here to say that this comparison was such as would do credit to any of the members of the Bureau of Standards to-day. I now quote from his report, made about 1831 or 1832, to the President of the Senate upon the work that he was delegated to do. The State Department, through gifts from other nations, had a few standards, which he involved in this comparison.

Vouchers upon the origin and authenticity of the standards included in this comparison, other than those from the State Department.

1. Standards from the collection of instruments for the coast survey.

The accuracy of the unit of length measure to be employed in the coast survey, was such an indispensable requisite, that I took, of course, all necessary measures to obtain it, when I was in Europe to procure instruments for that work. The French mètre is the absolute unit of length which has been the most accurately determined. It is presented multiplied in the original by 15 bars of iron and one bar of platinum, cut to that length; and the temperature of melting ice, or 32° Fahrenheit, is the standard temperature for the same.

The English standard of length consisted, until the late changes made in England, in a brass scale of undefined length, divided into inches and tenths of inches, the mean of which, for any length, measured upon as many parts of the scale as found proper, was considered a standard of that length, at the standard temperature of 62° Fahrenheit. As it was naturally desirable that the distances of the survey would be given in both lengths, I caused Mr. Troughton, in London, to construct the scale of 82 inches English, quoted in the preceding list, which he made by doubling his own scale, after having made a new table of errors, to correct this transfer by it, from the same he had already divided the scale of Sir George Shuckburg Evelin, which has served for his comparison in 1795, and since for those lately made by Captain Kater. This scale, the accuracy of which within itself is exhibited by the statement to be seen in the detailed account of the operation of the present comparison, forms, therefore, a direct link to unite the present comparison with the late English determinations of the yard and pendulum, as well as the general means of comparison.

Mr. Lenoir, the mechanician, of Paris, who constructed the mètres for the Committee of Weights and Measures, having, at the same time with those above quoted, standarded a brass mètre for himself, at the temperature of 32° Fahrenheit, I procured a copy of the same, which was compared at the Observatory of Paris with the mètre there preserved. The certificate signed by Messrs. Bouvard and Arago states it to be too short for 1-100 part of a millimetre, or 0.000393810 of an English inch, and is dated 16th of March, 1813.

The iron toise was also made by Lenoir, and compared at the Observatory at Paris by Messrs. Bouvard and Arago, under the above date.

Having by the above so much of the standards, I found it proper, and hoped in future useful, to make the small additional expense of procuring also accurate weights. The balance of Troughton, with grain weights, which were again exactly verified by him. Of Fortin, the mechanician in Paris who had constructed the weights, and litres modèles for the Committee of Weights and Measures, I procured two subdivided cubical kilograms, with the decimals to the milligramme, and two litres modèles; by procuring two individuals of each kind, I obtained the indication of the degree of accuracy with which they are made, and their coincidence has been very satisfactory.

Right there is an indication that he was an experienced metrologist. He got two of the articles in order to find their variation.

2. The Philosophical Society in Philadelphia is in possession of several, and, in their kind, the most valuable standards; which I brought with me to this country on my arrival in 1805. I was favored with a loan of them for the present comparison.

The iron mètre is one of the original standards made by the Committee of Weights and Measures, as quoted above.

That part of the work being under the special direction of Professor Tralles, my friend and teacher in mathematics, member of the committee, as deputy from the Helvetic Republic, he made three of the above iron mètres more than what was required for the deputies present; one of these he made a present to me, which is the one here compared. It is, therefore, fully accurate, and of original authenticity.

The same is the case with the kilogram of the society. Its origin and history is in every thing exactly the same, except that it was Mr. Van Swinden, deputy from the Batavian Republic, who had the special care of their construction. The one present is No. 2, as a label in the box indicates. A private paper of Mr. Tralles, in my possession, not yet printed, detailing the ultimate comparisons of the mètres, the kilogram, and also those of the toises, designated this kilogram No. 2 as entirely exact.

The toise of Canivet, of 1768, I purchased in Paris, in 1796, from the heirs of the late Mr. Dionis Dusejour. It is in perfect preservation, being guarded by a matrix, so as never to expose its determining ends; it has marked on the reverse the double length of the pendulum under the equator, which indicates its having been designed for the comparison; when, at the epoch of its construction, this length was proposed as an unit standard from nature.

The society possesses, also, two copies of the well known toises of Lalande, made by myself, on the occasion of my triangulation of Switzerland in 1791. They were included in my comparison for the coast survey, but I did not find proper to make them enter into the present.

3. The Treasury Department acquired of me lately the standards which I had yet in my possession for my private use. The scale of 52 inches has also marked upon it the distance 51.2 from Sir George Shuckburg's scale. On account of that, I immediately purchased it from Mr. Troughton, when I saw it in his workshop, as it furnished a direct comparison with that scale; which has become of great importance by its use in the English comparisons.

Before I delivered the instruments for the coast survey, when that work was interrupted, I laid off upon it, 1st, from the middle of the large scale of Troughton the divisions in tenths of inches; 2d, the mètre from the brass mètre of Lenoir, in the coast survey collection; 3rd, the half toise from the half of the toise of Canivet.

The yard between platinum dots, I procured from Mr. Troughton, upon yet imperfect information upon the new yard established by the last English determinations, which proved what since became public; and the result of the present comparison shows: that it is actually only the old exchequer yard that was adopted: it is less than the exchequer copy of the State Department, of Jones, only by 0.00005275 of an inch.

The Amsterdam foot was marked upon it, on account of its frequent occurrence in the measurement of land and lots in New York upon old titles; and for this also its comparison result, given in this report, may be useful.

The brass mètre of Fortin I had acquired in this country from an European scientific gentleman, finding it in full good preservation. Fortin certifies it to be fully correct, under date 24th December, 1824.

Knowing the occasions I would have to compare standards, I had an iron bar constructed for myself, at the same time as those intended for the base measuring apparatus, which are all equal in breadth and thickness to the original iron mètres of the committee. This I intended to convert into a mètre for myself; when near, still above the proper length, it was taken up in the comparisons made for the coast survey, where an additional mètre was needed. Only on the occasion of the present comparison, I had the opportunity to adjust it fully, it being besides necessary for the comparison of the iron mètres by combination.

The troy pound I had brought with me to this country in 1805. It was made in Switzerland by a careful artist of Arau, Mr. Esser, after one that I had received from Mr. Troughton. Mr. Patterson, Director of the Mint in Philadelphia, compared it in 1805, with the troy pound of the Mint then in use, and found them exactly equal; but the Mint pound having since been in frequent use, while I preserved mine always carefully, on a comparison made, in the fall of 1830, the former was found considerably lighter.

4. The *troy pound of the United States' Mint at Philadelphia*, was made by Captain Kater, purposely for the Mint, upon the request of Mr. Gallatin, who considered this an authority far superior to the comparison of the Exchequer. The weight is in form similar to those made by Kater for the Exchequer, and enclosed within its box, in a brass form, upon which is engraved, Pound Troy, 1824, Bate, London. A detailed certificate of Captain Kater, dated London, 30th June, 1827, certifies to the comparison, and quotes the ultimate experiments with the same. A certificate of Mr. Gallatin, of the 24th July, 1827, testifies to its origin, and President Adams, under date of 13th October, 1827, to the safe and undisturbed reception thereof, so as to warrant full trust in its accuracy.

The *mark* weights of *Madrid* and of *Mexico* were also received by authority; the former, called marco-castilliano, is one of the two made at Madrid upon orders of Mr. Everett, ambassador of the United States, and found exactly equal to that at the Madrid Mint, as certified by him under date of 30th January, 1827. It arrived entirely safe and well preserved at the Mint of Philadelphia, as testified by the officers of the Mint, 9th August, 1828.

The *Mexican mark* was procured from the Mint in Mexico, with the standard of which it was found exactly equal, by Mr. Poinsett, United States' ambassador there, as testified by him under date of 30th February, 1828. It was received in perfect order at the Mint, as testified by the officers thereof, 9th August, 1828.

5. When the present comparison was already in a considerable state of forwardness, information was received, that there was still extant, in the custom-house of New Hampshire, a set of standards of weights and capacity measures, from the old provincial Government of that State. Upon the request of the Treasury Department, they were forwarded here by the collector, and proved a valuable acquisition to the object of this comparison.

They bear generally the stamp of G. I., besides that of the Exchequer; are, generally speaking, in good preservation; but unfortunately, since the report inserted of them in the Report upon Weights and Measures of the honorable late President, John Q. Adams, they were sent to Boston for verification, where several capacity measures were reduced, by means of lead fixed in their bottoms. This was evidently intended to bring them down to the newer standards, which appear generally to have suffered a reduction by negligence. The weights appeared not to have been altered, except the 14 and 56 lb., which had a little lead added to the bottom.

6. The two brass mètres of the Engineer Department have no special authority or certificate, except the name of the maker, Lenoir, engraved upon them.

7. The city of New York having procured a set of copies of the Exchequer standards, they were lent to the State Government to make standards for the State from them.

And so on. A number of others were secured in the same way, showing that he realized that the first step necessary was to procure the most accurate scientific standards in existence.

We will now pass on to another of these replies to the auditor's criticisms. Looking through this most remarkable report we find him charged, by implication at least, of selling his books to the Military Academy at West Point, and again selling them to the Coast Survey. And this is his reply:

The manner in which this article of the sale of F. R. H.'s books is treated is such as he must *repel* as a highly improper attack upon his character, in consequence of which it must become one of the articles of *special investigation*, because it is thereby intimated as if he had made a double sale of the same books to the government. Notwithstanding he does not consider himself bound to *give account to any man* upon the manner in which he disposes of his property, he has also no secrets, and therefore will place here the whole history of his library, of which much is contained already in former communications. F. R. H. had (as is still easily proveable), from the age of 16, in Europe, begun the selection of a scientific library, which, shortly before he left his native country, amounted to nearly 5,000 volumes; all the most valuable classical books in their branches, in diplomacy, history, law, mathematics, natural philosophy, and ancient classics; not a single common poet, novel, or such like ephemeral book, being in it. Intending to leave the country where the diplomatic and law part of his library applied to his occupations in public life, he sold that part of it, and came to this country in 1805, with about 3,000 volumes of books of all the most select ancient and modern classical, in natural and mathematical sciences, a great number of them very scarce, and no more to be obtained, but accidentally, as he had the occasion for during the time of his studies in Paris, Göttingen, etc., and paying often $15 and more for a volume; all of which can be proved by living witnesses in this country. Of the diplomatic part remaining some were sold to the library of congress.

Besides that, he brought a number of instruments, standard weights and measures, which are now yet the only equally accurate and authentic ones in this country, whence they are employed by him as principal means for the comparisons of weights and measures, that have been presented by him in the report to congress upon that subject. (See the report itself, which was so highly approved in Europe and in this country.)

This attracted to him the men of science in Philadelphia, who shortly after selected him a member of the Philosophical Society there without his knowledge; these declared that such a valuable library and collection of instruments had never before come to this country (and it can be added, never since); they gave to the then President, Jefferson, information upon him, with a notice upon his former life, as proved by his documents, among which were the notices of the triangulation he had begun in Switzerland in 1791, and been interrupted by the Revolution.

This cricumstance gave life to the idea that had been entertained then already for some years, particularly by President Jefferson and other eminent men of that time, to get, by means of F. R. H.'s experience, the so much needed work of the Coast Survey executed; wherefore he was spoken to, before the law itself was proposed that passed in 1807.

When in 1811 F. R. H. was sent to Europe for the procuring of instruments and books for the government, he also augmented his private collection; but finding it proper on his part to use the public funds intrusted to him only for the greater objects of immediate want for the Coast Survey works, he bought on government's account only the closest needed books of those times, as he also referred many smaller instruments to be procured later, when needed.

In selling what he called the remainder of his library, to the Military Academy at West Point, (the history of which transaction is even not very edifying,) it could not be expected that a man accustomed to books for his companions from childhood, would divest himself of the last book he had. It is besides evident that he, in such a case, will reserve by preference just such books that are the closest connected with his favorite occupation. In the present case, therefore, naturally just, the most valuable and most practical works for geodetical, astronomical, and similar purposes, were reserved.

Had not the Coast Survey been again intrusted to F. R. H., and had he not thought he could this time trust upon the stability of the government in maintaining a measure, taken with proper reflection and consultation of past experience, he would never have thought of parting with these books for the benefit of the work. This is what is refused, and even tried to be turned into *suspicion against his character.*

So far, however, as the accounts are concerned, (the other part belongs to the called-for investigation,) this difficulty is fully settled. F. R. H. has returned the money, and will take back the books again. He will never more offer or sell them to the government, nor direct the purchase of a single book for government's account, as it is decided by the Fourth Auditor that the assistants of the Coast Survey shall not be provided with means of instruction in their functions.

If any man of sceince had read and compared the two catalogues which both are among the documents of the Coast Survey, that of the books received from West Point, and that of those transferred by F. R. H., he would immediately have seen the distinctly different character of the two collections, and that many of the books of F. R. Hassler's transfer were not even in existence at the time of the sale to West Point, many being presents from the scentific men and societies in Europe, and even from the Admiralty of England.

And I again ask your indulgence just for a moment. You all know how, periodically, the question of carriages and automobiles comes up in the Government service in connection with the auditing of accounts. I will read another of these documents, because of the interesting informaticn it contains regarding the history of Mr. Hassler. This one is in reply to charge No. 9 by the Auditor's Office of the Treasury Department concerning the purchase of a carriage. Superintendent Hassler goes on to state:

The purchase of the carriage, or rather Jersey wagon, with springs, is for the first onset grounded upon a special letter to that effect, addressed to the Treasury Department the 23rd November, 1816. In 1832 this was fully sanctioned by the reference of the Treasury Department to the former arrangements that are confirmed by it, and to propositions given in at that time by F. R. H. sanctioned by the reference to them. The whole history of the carriage (which Colonel Abert can attest) is the following:

It was at first intended to carry the instruments by hand from station to station, like F. R. H. was used to have it done in the rugged mountains of Switzerland. This, however, was found by far too cumbersome and *expensive* (as already stated). The habitual construction of carriages was found, as well in form as in softness of motion, entirely inadmissable, as much so as common wagons. To transport safely several delicate instruments of about one hundred and more pounds each, with a number of smaller ones, etc. which would have been useless if not transported carefully over bad mountain roads, was the question to be solved. Therefore, in consultation with the then accounting officer, (Colonel Abert, who can testify to every point,) it was decided to propose a peculiar conveyance, to be constructed for that purpose, which was immediately agreed to by the Treasury Department, by answer to F. R. H. that he must be the best judge upon the means of conveyance: that this included also the horses is an evident consequence—(see the letter quoted). Then F. R. H., with the assistance of a man in his own wages, placed in a corner of his room in Newark all the larger instruments, with their boxes, that were to be used at every station generally, and directed the coach-maker (Campfield, of Newark, yet living) to take the measure for the box that would hold them, just snugly pressed against each other, so as to prevent all jarring and shaking; and to mount this in the form of a kind of barouche, or what it may be found proper to call it, with a top folding down, for the shelter against rain when up, and to pass under the branches of trees when down, which was an absolute requisite,—for which, as also for greater security, the wheels were made lower than habitual, and upon the wide rut; and hang it upon good C springs and thorough braces, etc.; the instrument boxes having to stand even, while to obtain the proper effect of the springs and thorough braces requires a rounded bottom, the space between formed a double bottom, in which the smaller instruments, tools, journals, etc. always were transported; for the telescope, a large sword-case (as generally called) was added to the back of the carriage-box. This all forms the odd appearance by which this conveyance is known, as well as by the complete absence of all luxury. This proves all: that the second article of the older contract, quoted by the Fourth Auditor's letter, has nothing to do with the horses and the carriage, which were specially authorized, once for all, and confirmed by the agreement of 1832, which positively says—that the arrangement of the first agreement shall be continued, and refers particularly to F. R. H.'s previous propositions, in which these objects, with many others, were mentioned as necessary; therefore also the resulting expenditures passed in the accounts rendered to the First Auditor, who had all the necessary papers to assist a proper judgment, which the Fourth Auditor must obtain, if he has them not.

The above carriage having been sold at auction in 1819, after the Coast Survey was broken up for the first time, and while F. R. H. was engaged at the boundary line with Canada, he purchased it, together with the two horses that were sold at the same time, because it was needed for the use in that work; but his leaving that employment left him the whole upon hand as a useless loss, and he used it only to move to his farm in Jefferson county, New York, where it remained well sheltered until the Coast Survey came again into his hands in 1832, when it was immediately brought to his former maker in Newark, N. J. New wheels and axletrees were made to it, and it was otherwise put in full repair, at the expense of F. R. H., so as to be really better than a new one would have been, obtained at that time. Then it was again transferred to the Coast Survey service, its original destination, where it might long yet render service in its destined capacity. The price set upon it, which the coach-maker who mended it said was cheap, was $500. It stood F. R. H. in the amount of $1,000, by the unfortunate circumstance of the failing of the aim of its employment in the northern boundary line.

The economy which this transfer and the purchase of the horses for the Coast Survey effect was very great, as the work could immediately proceed, while the construction of a new carriage of the same kind, which would have been *unavoidable*, which would have cost far more, and have delayed the whole remainder of the campaign of 1832, and the hire in the meantime would have cost more than all these purchases.

And there are still more of these intensely interesting documents.

When I first came to Washington in 1898 and visited the Coast and Geodetic Survey I was impressed with the character of the weights and measures instruments. Congress, after Mr. Hassler's report, directed the Coast Survey to furnish all of the States with copies of the standards which the Secretary of the Treasury had constructed for the customhouses. He constructed these copies for the customhouses without congressional direction, but was directed to furnish them to the States. This was really the beginning of the Office of Weights and Measures as a separate institution, but, of course, the Office of Weights and Measures was, as before, under the direct supervision of the Superintendent of the Coast Survey. It served the Survey as well as the Customs Service and to a very limited extent the public.

The entire work of constructing these standards, and the balances by which they were used, both for the States and for the customhouses, is one of the most remarkable pieces of work of that kind ever done, and it was accomplished under the most trying circumstances.

I have been told by an officer of the New Jersey Zinc Company that the hole still exists where the zinc was mined for the brass; that the copper was brought from Switzerland, and that the workmen were imported from abroad. But this I do know, that the work, done by hand in many cases and with the crudest sort of tools, was equal in many respects to that of the best workmen of to-day.

The work of the weights and measures division was forwarded by the Superintendents of the Coast Survey, notably by Bache, Hilgard, Mendenhall, and others, and in this Office of Weights and Measures there was a direct line of succession, as it were, one or more persons at all times being directly engaged in this work of metrology, and following the principles laid down by Superintendent Hassler. The Bureau of Standards inherited not only the Office of Weights and Measures, but inherited its personnel, and with it the chief of our weights and measures division at the Bureau of Standards, Mr. Fischer, and he, in a metrological sense, is a direct descendant of Mr. Hassler. It has remained for the Bureau of Standards to make useful those standards which were sent to the different States.

When the Bureau of Standards was established, we were surprised to find that the States were doing little with these standards; things were at a standstill. And why? For the same reason they were at a standstill in the National Government until Mr. Hassler took charge. There was no provision by the States for their use. They were considered as souvenirs and stored away. It was necessary to have the personnel and the mechanism for making these standards available to the public, and that is what our Office of Weights and Measures is doing to-day, directly and indirectly through State officials.

I want also to mention another fact, which I think ought to be known and placed to the credit of the Coast and Geodetic Survey. When I first came to Washington and met the Superintendent of the Survey, he asked me to join his force temporarily and make a report as to what could be done to place the weights and measures work upon the basis necessary in the present day of precision measurements of all kinds. I made two reports, one based upon the enlargement of that work to the extent possible in its present quarters, and dealing solely with weights and measures of the kind we have been speaking. The other suggested the establishment of an institution having weights and measures functions in the broadest sense, covering measurements in the various lines of physics, the properties of materials and physical constants, etc., data which are needed to-day as much as standard pounds and yards.

It was the Superintendent of the Coast and Geodetic Survey, Doctor Pritchett, who saw that the second plan was the preferable one. He recommended it to the Treasury Department, and the Secretary of the Treasury directed that a bill be drawn looking toward the establishment of such an institution. Here, again, was a thing remarkable for a Government bureau, the suggestion of the separation from it of a part of its work. I think those of you who are connected with Government work will realize just what that meant.

The history of the Bureau of Standards is well known to you. It was established in 1901, and its principal work is standards, standardization, and methods of measurement, the result of which is the introduction of scientific methods and precision where formerly inaccuracy or even the absence of measurements prevailed. To-day the relations between that Bureau and the Coast and Geodetic Survey are as intimate as ever the relations were between the old Office of Weights and Measures and the Coast Survey. The Bureau of Standards serves the Coast and Geodetic Survey, as well as many or practically all of the other bureaus of the Government service; they are all working harmoniously together in this respect.

In conclusion, I have three or four slides showing some of the early standards. It will take but just a moment to show them, but before projecting them upon the screen I wish to make the suggestion that at this centennial celebration the Coast and Geodetic Survey and the Bureau of Standards unite in securing the establishment in this city of a suitable memorial to its first superintendent, F. R. Hassler.

These views will be very much enlarged, but it should be borne in mind that the lengths are in yards, feet, etc.

Figure 4 is the Troy pound, procured in 1827 from England by Albert Gallatin, then minister of the United States at London, and used as the standard for the coining of money until just a few years ago. The avoirdupois pound adopted by Mr. Hassler as the standard was derived from this Troy pound, the Troy pound having 5,760 grains and the avoirdupois pound 7,000 grains.

Figure 5 is a view of the United States prototype kilograms, showing the way they are kept at the Bureau. The one on the right is known as kilogram No. 20 and that on the left is known as kilogram No. 4. They were acquired in 1890 and are copies of the international standard kilogram in the custody of the International Bureau of Weights and Measures situated near Paris and under the control of an international committee, one of the members of which is the United States. There are now 26 countries maintaining at joint expense the International Bureau, established in 1875, for the custody and comparison of the fundamental international metric standards, to which all metric units, measurements, and national standards of the world are referred. The prototype kilogram superseded in the United States in 1893 the old Arago kilogram used since 1821, in which year it was procured for this country by Mr. Gallatin while minister to France.

Figure 6 represents one of the balances. It was just as necessary to have balances as to have weights. These balances were made and distributed to the different States.

Figure 7 represents the new platinum-iridium meter. It was brought to this country in 1890, and adopted as the standard for all measurements in 1893. All of our measurements are referred to this meter. One of the most important things that the Coast and Geodetic Survey ever did in connection with the subject of metrology was to suggest the fixing of the relation between the meter and the yard. This was done under Superintendent Mendenhall. It was promulgated by Executive order, so that to-day the meter, representing as it does the most refined standard, serves as the standard length for both systems of measurements.

Figure 8 is the committee meter, brought to this country by Superintendent Hassler in 1805 and presented by him to the American Philosophical Society of Philadelphia shortly after his arrival. When he was put in charge of the Coast Survey, he secured the bar from the Philosophical Society, and it remained in the possession of the Coast and Geodetic Survey until the establishment of the Bureau of Standards in 1901. The committee meter has since been superseded by the new platinum-iridium meter.

FIG. 4.—TROY POUND STANDARD

FIG. 5.—STANDARD KILOGRAM

FIG. 6.—STANDARD BALANCE

FIG. 7.—PLATINUM-IRIDIUM METER

FIG. 8.—COMMITTEE METER

FIG. 9.—BRONZE YARD No. 11

FIG. 10.—SET OF HISTORICAL STANDARDS

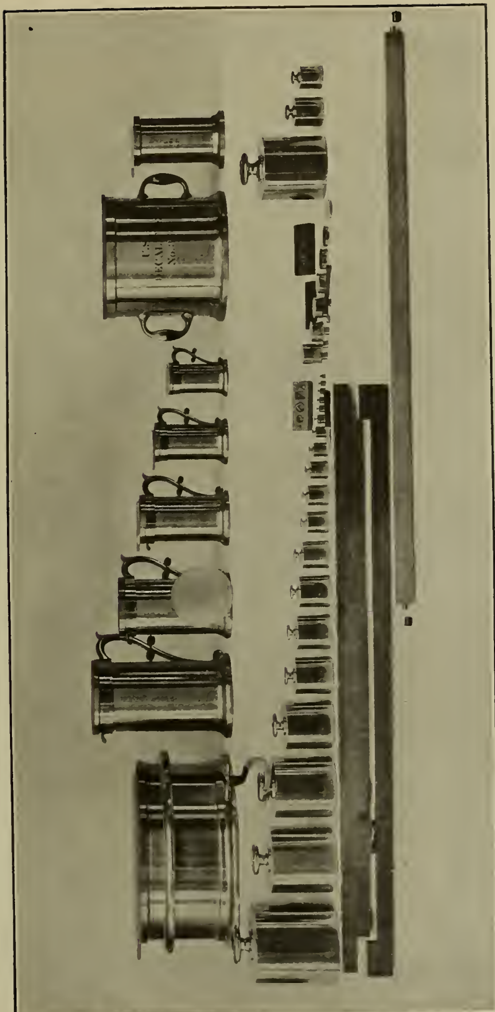

FIG. 11.—SET OF STATE STANDARDS

Figure 9 is the brass yard, known as bronze yard No. 11, sent to this Government by Great Britain in 1856. It was the standard of length in this country until the meter was adopted. You will observe in the enlarged view of the bar, which is now on its side, a circular recess; in the bottom of the recess is a small spot; that is a plug of gold on which is a fine line marking the end of the bar.

Figure 10 shows some of the old standards, probably from the State Department weights and measures.

Figure 11 is a set of the standards furnished to each State. There is the half-bushel on the left, the liquid measure on the right, etc. I have never seen better work by an instrument maker than this set of standards.

Mr. Jones: I am sure we are grateful to Doctor Stratton for telling us of the early history of the Bureau of Standards and its past relations to the Coast and Geodetic Survey.

I am very sorry that Admiral J. E. Pillsbury who was to speak to us next, is ill, but I am glad to say that his paper has been sent us and it will be made a part of our record and printed later in an official document.

OCEAN CURRENTS AND DEEP-SEA EXPLORATIONS OF THE UNITED STATES COAST AND GEODETIC SURVEY

Rear Admiral Pillsbury: I have been honored by an invitation from the Superintendent to lend my assistance toward the proper celebration of this, the one hundredth anniversary of the establishment of the Coast and Geodetic Survey.

While my experience was varied between the hydrographic inspector's office and the coast pilot division, and afloat, it was mostly the latter. For five years I was in command of the steamer *Blake*, each winter of which, at least, was devoted to the investigation of the Gulf Stream currents and those contributing thereto. It is of the work of the Coast Survey in this direction that I am to speak to you this afternoon.

Columbus first noticed the currents contributory to the Gulf Stream in both the eastern and western Caribbean. Ponce de Leon found it in the Straits of Florida when he was in search of the "Fountain of Youth." Alaminos, one of Cortez's captains, took advantage of knowledge of the stream in the endeavor to make a quick passage from Mexico to Spain with dispatches. In the north the Cabots, about 1500, realized the fact of an easterly current in crossing the Atlantic. Later, the British divided their American colonizing voyages into two parts because of the currents in the northern Atlantic, the New England ships crossing in high northern latitudes, the Virginia ships running south to the trade winds and even sometimes into the Caribbean and thence north to their destination on the southern Atlantic coast.

To Benjamin Franklin is due the credit of the first examination of the Gulf Stream between New York and Europe, his method being to take the temperature of the water frequently as the vessel proceeded on her way across the ocean either east or west. His idea was obtained from Nantucket whaling captains who observed that certain whales were found near the warmer water but not within its limit.

Later, Doctor Blagden of the Royal Army; Pownall, formerly governor of Massachusetts; Humboldt, Colonel Sabine, Major Runnell, and others also investigated the Gulf Stream, and most of them published their ideas. All of them were based upon the temperature of the surface water, upon the drift of bottles, or upon the difference between the observed and the dead-reckoning position of ships traversing the ocean.

It was not until the administration of Professor A. D. Bache as Superintendent of the Coast Survey that a systematic examination of the Gulf Stream was begun. In 1845 the *Washington* was commissioned under the command of Lieutenant C. H. Davis, afterwards rear admiral and superintendent of the Naval Observatory. The orders he received were most comprehensive. They were to determine its limits, surface and subsurface, whether constant or variable, depending upon winds, how recognized, whether by temperature, soundings, forms of vegetable or animal life, or specific gravity of its water, etc.

From 1845 to 1853 various vessels of the Survey under many commanders continued the examination from the Straits of Florida to and beyond Cape Hatteras. The depth of water and the character of the bottom were determined, but the actual limit of the flow was assumed to be where the water was found to be warm. The highest temperature was assumed to be the axis, and a considerable fall on its inshore side its limit. It was also found that there were certain bands of varying temperature, warm and cool, and these were assumed to be all within the limits of the stream itself. In a map published at the time, the stream is represented as issuing from the Straits of Florida, where it is about 40 miles in width, and spreading out in the warm and cold bands until it is about 120 miles in width southeast of Hatteras. The only record of the velocity of the current was the difference between the dead-reckoning and the astronomical positions of the vessels engaged in the work.

After 1860 Gulf Stream investigation ceased until 1867, when Professor Henry Mitchell of the Coast Survey sounded between Key West and Habana and observed the current to 600 fathoms by a new method. He used three cans, one weighted and suspended from the second of equal dimensions on the surface, while a third can was connected with the one on the surface by a light reel and log line. Upon signal, the floats were released for a given time and the difference between the single can and the pair, as retarded by the can below, gave data for calculating the subcurrent. An anchored boat or buoy was used as an initial point whenever the depth of water permitted, and this method of observing currents was continued in use by the Survey for 15 years or more in offshore or deep-sea work.

The method, however, was one which lends itself only to what may be called tentative results. Observations were, as a rule, confined to a single set at various depths at the same station, and although sometimes they were continued longer, as, for example, in the Gulf of Maine, where the water is shoal, in deep-sea work the results, because of lack of continuity, were of no value in establishing the laws governing the flow.

In old times it was the practice on board all men-of-war, when on deep-sea voyages, to throw a bottle overboard at noon each day containing a paper stating the position of the ship with a request to the finder to forward it to some United States official with a statement as to the locality where found. The Survey had bottles made of convenient size and heavily ballasted in the making so that they would float mostly submerged and thus be but little exposed to the influence of the wind. They were, however, still floating on the surface and were subjected for their course at sea not so much to the direct force of the wind as to the wave caused by it, be it ever so light.

His Highness, the Prince of Monaco, used this method, at first to discover the cause of the departure of sardines from the west coast of France, and later, to determine the currents in the eastern Atlantic. His floats were barrels, bottles, and especially constructed copper globes. The barrels and globes were ballasted by a weight suspended by iron wire several feet below the surface, so that by the time the pair accumulated an undue quantity of barnacles and grass the ballast would become detached through the rusting of the suspending wire and the float itself had thus a longer life. He put overboard from his yacht about 1,700 of these floats during the three years 1885 to 1887, the first year off the coast of France, the second 170 miles northwest of the Azores, and the third between the Azores and Newfoundland. This was the most extensive and systematic endeavor to search out the eastern Atlantic currents that has ever been undertaken by this or any other means.

We now come to the time when the Coast Survey decided to make the endeavor to observe the Gulf Stream currents by means of a vessel at anchor and continued as long as possible at each station in order to arrive at some conclusion as to the variability of the flow. Professor Hilgard, the Superintendent, gave every support to the hydrographic inspector, Commander Chester, in arranging the details of the investigation, and Lieutenant Fremont, in command of the schooner *Drift* was ordered to carry them out.

The vessel was supplied with about 700 fathoms of wire rope three-quarters of an inch in diameter, and instructions were issued to anchor at various places along the coast near the 100-fathom curve and also in the Gulf Stream east of Jupiter Inlet, Florida. The *Drift* was a deep-keel schooner of about 100 tons. Not having steam power, the operations of anchoring and heaving in this wire rope was by hand power alone, so the difficulties to be overcome for the officers and crew were very great. In spite of these, the *Drift* occupied five stations between Jupiter Inlet and Memory Rock, Bahamas, the greatest depth being 400 fathoms. The current observations were still by the method of floating cans attached to a log line. It was discovered that contrary to expectations the maximum flow was not at the supposed middle of the stream, but was to the westward of it. The depth here was only 190 fathoms and the location some 10 miles to the westward of the supposed axis.

Although this attempt at arriving at a knowledge of the actual flow of the water was by inadequate means, it was the greatest stride that had been made toward the solution of the problem, but the use of a sailing vessel for the purpose was found to be impracticable. The delay in arriving at a station when good weather appeared, and the fact that this was impossible in a calm, which was the very time when observations would be most accurate; the long hours necessary in heaving up the anchor by hand power, and the danger to the vessel in the case of a sudden gale while getting under way—all of these reasons brought about the decision that a continuation of the work demanded the use of a fully equipped steamer. The *Blake* was decided upon, as she had been engaged in dredging and sounding in the deep sea and, being fitted with hoisting engines, etc., but little change would be necessary to fit her for the new duty.

The changes, however, were made so that by steam power and a lighter anchoring rope the *Blake* could be quickly anchored in any depth required. In getting under way the speed of heaving in at first was 10 or 15 fathoms per minute, but after the anchor broke ground up it would come at the rate of 50 to 75 fathoms per minute. When you think of Lieutenant Fremont in the schooner *Drift* heaving in the anchoring rope with a hand windlass at the rate of 2 or 3 fathoms a minute, you will realize the advantage of steam for the purpose. The *Blake's* deepest anchorage was 2,300 fathoms and many were made at about 1,500 fathoms. This would have been impossible without steam gear.

Hitherto currents had been measured by means of cans, as before described. This was a long tedious method and one not fitted to systematic research. A current meter was therefore devised which was composed of revolving cones to register velocity, a rudder that would always tail to the direction of the flowing water, a compass below the rudder, which of course always pointed to the north, and an arrangement for locking all the elements of the machine upon beginning to hoist it to the surface. With this instrument observations were taken at various depths in succession for 30 minutes at each depth from 15 to at least 130 fathoms and repeated as long as the vessel remained at anchor, while a second instrument was used for continuous observations at a depth of 3½ fathoms.

A project for the systematic survey of the stream was submitted to the Superintendent and was carried out as far as could be in the time allowed. The first section of the stream to be attacked was at its narrowest point (between Fowey Rocks, Florida, and Gun Key, Bahamas), in order to try to establish the laws governing its flow where it was surely all Gulf Stream. Other sections were between Habana and Key West, Tortugas and Cuba, and the Yucatan Passage to the westward, and various cross sections to the northward and eastward even as far as the Newfoundland Banks. There was also contemplated the investigation of the equatorial current and the flow into and through the Caribbean of the trade-wind current.

One season and half of another were spent off Fowey Rocks, and others were devoted to the sections of Habana, Tortugas, the Straits of Yucatan, the equatorial and Caribbean, off Jupiter Inlet and off Cape Hatteras, and many other incidental anchorages to add more knowledge to the sum total of information.

It was found in the first season that in the Straits of Florida the stream was apparently governed in the strength of its flow by the moon's transit in its daily variations and by the moon's declination in its monthly variations, and that, as Lieutenant Fremont had found off Jupiter Inlet, the axis was situated west of its supposed middle line. Later, in the Straits of Yucatan, where the flow is also north, the same conclusions were arrived at, and off Cape Hatteras, where the flow is northeast, it was found to be the same.

Then it was found at the axis in the Straits of Florida that while the average course of the surface current was north, the subcurrents had a slight deflection, depending upon the declination of the moon. At the time of the highest declination both north and south this was toward the left or westerly, while at zero declination it was toward the east. The changes were often but slight, but the mean of all observations showed this fact with certainty.

Another interesting feature of these small changes in direction of the subcurrent was the slight differences in temperature of the surface water. When the deflections were toward the left the surface temperature at the stations on the left of the axis was lower, and when toward the right the reverse conditions prevailed.

Later, one season and a part of another were devoted to the currents entering and within the Caribbean, these being contributory to the Gulf Stream. It was found that the water entering the Caribbean, as a measurable current, was much less than the volume pouring out through the Straits of Florida, which, by calculations deduced from many hundreds of observations, was determined to be 90,000,000,000 tons per hour.

There seem to be two contributory causes to this great current. Primarily, the cause is the northeast trade wind. This acts by surface friction on the ocean, which produces a shallow current (from 50 to 75 fathoms in depth). A part of this enters the Caribbean, thence into the Gulf of Mexico, and issues through the Straits of Florida into the Atlantic.

The other cause, however, is the wave action caused by the trade winds. When the wind is strong enough to make the waves break, the crest of the wave is thrown into the trough, which, in the Caribbean, where the trade winds are quite constant, amounts to a simultaneous movement of the surface to leeward, thus piling up the water on its western shores. This also escapes into the Gulf of Mexico to help swell the volume of the current.

There is another addition of the Gulf Stream when it reaches the North Atlantic which comes to it from the part of the trade-wind current flowing north of the West Indian Islands and sweeping around east of the Bahamas joining the stream south of Cape Hatteras. Its temperature is higher than the stream because it is slow moving; it is not interferred with by the bottom nor mixed with cold water by slight changes of direction of the lower currents to such an extent as the stream itself is in the confined waters of the Straits of Florida. It was this warm outside flow that probably led Professor Bache to conclude that the Florida Stream spread out over the Atlantic as soon as it had room, when in fact it has about the same width off Hatteras as off Fowey Rocks. It is possible, however, that this addition of heated water is of greater influence on the climate of Europe than the stream itself.

We all know that the effect of atmospheric pressure on the ocean displaces the water on the coast, as shown by abnormal high or low tides. These fluctuations of the barometer were also indicated in the Gulf Stream flow. In a final analysis of all the observations it was discovered that in every instance where there was great departure in velocity from the averages established by the observations, there were great differences in the barometer between the Gulf of Mexico and the Atlantic. The departures from the average were usually in the lower currents or at the sides, a low barometer in the Gulf of Mexico lessening the flow.

That the Gulf Stream is governed by absolute laws no one can doubt. After the first two years of work in the Straits of Florida, when it was thought that some of these laws were indicated, anchorages were made there with a previous prediction as to the strength of current to be expected, and the hour of its maximum flow, and in every case the prediction was verified.

Every two or three years the newspapers print stories of change of climate on the New Jersey coast, or Nantucket, and give as evidence not only high temperature but the fact that Gulf weed has been seen near the shore. The home of this marine plant is the Sargasso Sea, where it grows and develops on the surface. It is blown by the winds and thrown to leeward by the waves until some of it reaches the Gulf

Stream north of the Bahamas. Carried north by the stream to beyond Hatteras, a southerly wind carries it beyond its inshore boundaries toward the northern coast, and with the Gulf weed also comes the warm surface water. It is believed, however, that the Gulf Stream current itself remains on its course practically the same, subject to its daily, monthly, and yearly variations in velocity, but no material variation in direction. This great current is as nearly immutable as any of the forces of nature with which we are familiar at the present time.

A story of one of the many experiences of the *Blake* in her deep anchorages may be interesting. Bad weather had driven her to a lee under Great Isaac on the Bahama Bank some miles north of the Bemini Islands. In the afternoon, when the weather was moderating, we saw a small sloop standing toward us and when she luffed up under our stern there was a hail asking: "Can I come on board?" Many ships are driven on shore along this part of the group, and, by the custom of the land the first wrecker invited or permitted to come on board had the first right to salving the ship. Our friend came on deck, and looked up and down, then said: "Thank the Lord I am first. Why, I lost $5,000 by not being first on board the *Mary Jones* when Bill Smith got ahead of me. Well, Cap, what's the matter," he said, "are you leaking or have you dropped your wheel?" "No," I answered, "we have just come in here for a lee, because it was too rough to stay at anchor out in the stream." He replied: "What are you telling me—do you think I am a fool? Young man, how deep do you suppose it is out there?" "Well we were anchored in about 400 fathoms when this northeaster began," and it required evidence as to the methods used before he could be convinced that we actually had been doing what we claimed.

Mr. Jones: Our next address will be "The United States Geological Survey and its Relation to the United States Coast and Geodetic Survey."

The Coast and Geodetic Survey is possibly closer to the United States Geological Survey than to any other bureau of the Federal Government, with one exception (the Bureau of Lighthouses). These two organizations have as their principal duties the mapping of the entire land and coastal water areas of the United States and Alaska. In carrying on this work the two bureaus have striven to avoid any duplication and to be of the greatest help to each other. There are, of course, many other important branches of the work of the Geological Survey which are absolutely necessary in the industrial and commercial development of the United States. As its name shows, one of its greatest fields of endeavor is that of geology. The results of its work in this field have made available to the Nation's industries the great mineral wealth of the country.

I take pleasure in introducing Doctor George Otis Smith, Director of the United States Geological Survey.

THE UNITED STATES GEOLOGICAL SURVEY AND ITS RELATION TO THE UNITED STATES COAST AND GEODETIC SURVEY

Doctor Smith: The relations of near relatives may be a delicate subject for public discussion. The two organizations of which I have been asked to speak this afternoon possess the same family name as well as certain family characteristics and in consequence are often mistaken one for the other. If one Survey buys a motor truck, the other gets the benefit of the advertising and the curious public remarks: "We don't see how the Geological Survey can afford it." Yet the relations of the two Surveys have been such for more than a third of a century and are such to-day that I welcome this opportunity for the younger to extend congratulations to the older organization. Were I to review in detail the common history of these two Surveys there are no chapters that I should better omit nor incidents that I might need to gloss over in order that my remarks should be in keeping with the spirit of this occasion. In short, the hearty congratulations that I bring are an expression of true appreciation of what the United States Coast and Geodetic Survey has been to the United States Geological Survey.

The two bureaus have much in common; the field of endeavor for each is nation wide; they are scientific in spirit and civil in organization; both are primarily field services, and the product of most of the work of each reaches the public in the form of maps. The similarity in official name also indicates a certain overlapping of function, which under some conditions might cause duplication of work. The fact that at no point in the twilight zone of superimposed jurisdiction has there been any wasted effort is good evidence that both these branches of the Federal scientific service have kept in mind the public nature of their work. It is because I realize that in the interrelations of these two bureaus the Geological Survey has been more often the beneficiary that I desire on this occasion to emphasize the gratifying fact that the two Surveys have worked in the cause of American science on a coordinated rather than a competitive basis.

In this connection I should mention the effort made 37 years ago to put on an economic and efficient basis the surveying work in the Western States. Under instructions by Congress the National Academy of Sciences considered all the work relating to scientific surveys and reported to Congress a plan prepared by a special committee, whose membership included the illustrious names of Marsh, Dana, Rogers, Newberry, Trowbridge, Newcomb, and Agassiz. This report, which was adopted by the academy with only one dissenting vote, grouped all surveys, geodetic, topographic, land parceling, and economic, under two distinct heads—surveys of mensuration and surveys of geology. At that time five independent organizations in three different departments were carrying on surveys of mensuration, and the academy recommended that all such work be combined under the Coast and Geodetic Survey with the new name Coast and Interior Survey. For the investigation of the natural resources of the public domain and the classification of the public lands a new organization was proposed, the United States Geological Survey. The functions of these two Surveys and of a third coordinate bureau in the Interior Department, the Land Office, were carefully defined and their interrelations fully recognized and provided for in the plan presented to Congress. Viewed in the light of 37 years of experience, the National Academy plan would be indorsed by most of us as eminently practical, and I believe the report stands as a splendid example of public service rendered by America's leading scientists. The bill which embodied the entire plan, however, failed of passage in Congress, although the part relating to the organization of the new Geological Survey was carried as a rider on the sundry civil appropriation act of March 3, 1879.

The newly organized United States Geological Survey began topographic surveys of the type that the National Academy had believed could best be executed by the Coast and Geodetic Survey, and the younger Survey has continued this kind of mensuration surveying until it has covered more than 40 per cent of the country and become the principal map-making bureau of the Government. In course of time, also, more or less legislative authority has been given for the control work, vertical and horizontal, needed for these topographic surveys, so that there has been evolved exactly the opportunity for duplication of work that the National Academy sought to prevent. The invitation to speak this afternoon on the subject of the relation of the United States Geological Survey to the United States Coast and Geodetic Survey is a privilege that I value highly, because it gives me the opportunity to point out that the result that Congress failed to insure by legislation has been attained by voluntary scientific cooperation.

In topographic mapping the activities of the older bureau stop at the coast, as its name suggests; its mensuration surveys elsewhere are purely geodetic and represent a refinement of method and an accuracy of result that is not necessary in the ordinary mapping of the country as a whole, although these engineering results are absolutely essential. Thus the earlier contribution of the older Survey to the needs of the younger was the furnishing of geographic positions with distances and azimuths; and in those days, before the typewriter was used or the photostat invented, those hundreds of pages of manuscript copies represented a large measure of cooperation. Later, the Coast and Geodetic Survey adopted the welcome policy of extending its geodetic control over areas where the Geological Survey had immediate need of such help.

At the request of the Geological Survey the Coast and Geodetic Survey established astronomic positions in Oklahoma, Arizona, Montana, Texas, Florida, and Oregon, a service of great value in furnishing the control for the topographic surveys, and though they were a part of the general plan of the older organization some of these positions were established before they were needed by the Coast and Geodetic Survey itself. Similarly, even this last year the Coast and Geodetic Survey has, at the request of the Geological Survey, extended its scheme of triangulation northwestward from Idaho to cover an area where control was particularly required in the progress of the topographic mapping.

In the earlier topographic surveys by the Geological Survey the elevations were based upon railroad data, which were found altogether discordant, and the extension of the precise-level lines by the Coast and Geodetic Survey provided the satisfactory vertical control that was immediately appreciated by our topographic engineers. Knowing the ready spirit of cooperation, we have from time to time made requests for help of this kind where it was most needed, and the record shows that every such request has met with prompt and willing consideration, and many times the plans of the Coast and Geodetic Survey have been so modified as to expedite the geodetic work in localities where it was most needed for our topographic work.

Thus, on our request, the transcontinental line of precise leveling was diverted so as to include Ogden. Lines were run from San Diego to Ogden, from Las Vegas to Reno, and from Ogden to San Francisco, as well as eastward from Arizona, northward from Ogden to Butte, and by way of Denver to Cheyenne. In Texas also the routes for the precise-level lines were selected with full consideration of the needs of both Surveys, and so this policy of practical coordination and spirit of hearty cooperation continue to yield results that are thoroughly satisfactory.

Members of the Geological Survey most familiar with these large contributions by the Coast and Geodetic Survey have estimated that the value of the geodetic work done by the older organization that would otherwise have necessarily been done by the Geological Survey has aggregated not less than a million dollars, and if the future engineering work of the Coast and Geodetic Survey, as now planned, is carried to completion another million dollars should be included in our total indebtedness to the older Survey. The point which I wish to emphasize is that by reason of a large degree of appreciation of the needs of the Geological Survey in its topographic mapping the geodetic work of the Coast and Geodetic Survey has been so planned and executed that this by-product of its operations has been conserved to the fullest extent possible, and as chief beneficiary the United States Geological Survey is thoroughly grateful.

The United States Geological Survey is proud of its pioneer work in aid of the development of the resources of Alaska, yet we are not forgetful of the fact that the real pioneer in Alaska was the United States Coast and Geodetic Survey, which started its work in Alaska 30 years earlier than our own Survey. The triangulation points and astronomic stations established by the Coast and Geodetic Survey have been used to control the topographic work in Alaska, and in several instances the geodetic work has been planned to meet specific requests of the Geological Survey. The Coast Survey charts have, of course, furnished the basis for the shore lines on the general maps of Alaska published by the Geological Survey, and, indeed, without these shore-line surveys it would have been impossible to compile an accurate map of Alaska.

It has been the custom of each of these Surveys to supply the other with photographic copies of field sheets of current work, which have been of special value in connection with maps about to be published. I am glad to record the fact that cooperation of this type has not been one-sided, but that the Geological Survey has furnished the Coast and Geodetic Survey with traverses of shore lines for incorporation in coast charts wherever the more exact surveys of the Coast and Geodetic Survey were lacking. Our topographic survey of the Bering River coal field, for instance, yielded data that were incorporated in the important Coast and Geodetic Survey chart of Controller Bay, which was published before the Geological Survey issued its topographic map of the larger area. In this way the public was served by receiving the information earlier than if the Geological Survey had insisted upon first publishing its own results.

The record of cooperation would be incomplete without reference to the transportation that has been furnished to Geological Survey parties. In 1900, for instance, six parties from the Geological Survey were taken to Nome and return on the Coast and Geodetic Survey steamers *Pathfinder* and *Patterson.* The testimony of the members of the Alaskan division of the Geological Survey is that the cooperation in Alaska has been as hearty and close as if the Coast and Geodetic Survey men and the Geological Survey men belonged to the same bureau.

In this connection, too, should be mentioned the earlier geologic observations made in Alaska by members of the Coast and Geodetic Survey, and chief among these scientist pioneers in Alaska is our own Doctor Dall, the credit for whose half century of scientific work under Government auspices is shared by the Coast and Geodetic Survey and the Geological Survey. In connection with its engineering work, also, the Coast and Geodetic Survey has made important scientific contributions that are distinctly geologic in character, and as geologists we are almost inclined to lay claim to Hayford's work on isostasy and Bowie's gravity determinations.

Every geologist who works in that attractive borderland where both the products of geologic processes and the processes themselves can be studied side by side—our continental shore line—has made large use of the Coast and Geodetic Survey charts, and as competent witnesses we gladly testify to the accuracy of these charts and we compliment their makers. Such geologic investigations as the study of changing shore lines, the history of the submerged margins of the continent, and the origin of sediments are being given attention by the Geological Survey, and all these studies must be based upon the surveys and resurveys made by the Coast and Geodetic Survey.

This brief review of the relations existing between these two bureaus may serve a larger purpose than the sincere expression of congratulations to the Coast and Geodetic Survey on this centennial occasion. For nearly four decades these two Surveys have been working side by side from Florida to Alaska without the specific statutory separation of functions deemed advisable by the National Academy and therefore with full opportunity to overlap their fields of operation, to duplicate work, and thus to waste public money. The fact that there has resulted economical coordination rather than wasteful competition stands to the credit of those in administrative control of the two bureaus, especially the superintendents and directors in the earlier years of this period of successful cooperation. Naturally, too, the spirit of hearty cooperation is equally shown between the scientific assistants of the two services.

In these days, when as American citizens we have so deep concern in the question of public regulation of private business—a nation-wide concern arising from a broadening appreciation of society's interest in the individual—it may be opportune for some of us as public officials to pause and consider the question of regulation of public business. Do we apply the same rules to our conduct of the business of these Federal bureaus that we advocate for the control of corporations? Some of us as scientists may feel that the comparison of a scientific bureau with an industrial corporation is forced if not absurd. Yet I trust that the two are alike in being not only productive but productive without undue waste. The National Academy report of 1878, to which I have referred, contains a significant phrase; in presenting to Congress the ideal for a scientific bureau as they saw it these scientists described the ideal plan as one that would yield the "best results at the least possible cost." Those few words express a practical administrative policy equally good for big business and pure science. And it is as illogical for a scientific bureau as for a munitions plant to shy at a cost-keeping system.

Here at the Federal Capital we have some two score scientific bureaus distributed through several executive departments. There exists no general plan of division of duties among these different agencies for public service, but as a fundamental policy we have pinned our faith to a sort of declaration of independence that all scientific bureaus were created free and equal. My acquaintance with bureau chiefs and their intimate advisers perhaps warrants me in describing them as possessing at least average ambitions, with the inevitable result that we have seen some fields of scientific investigation occupied by two or more bureaus, other and less attractive fields shunned, and even other fields claimed by those bureaus not best qualified to make the largest use of the opportunity for creative work. Among ourselves, we know of so many illustrations that no examples need be cited; each of us no doubt feels sure that we can at least specify the sins of other bureaus. This is the competitive system almost at its worst, because it is countenanced by men of scientific training and high ideals of public service. Fortunately, however, the two bureaus of which I have particularly spoken, as well as some others, furnish proof that there can be coordinated effort in Federal scientific work.

I have here referred to the business world because I believe we must apply some of the same rules to our scientific work. However slight may be the statutory limitations imposed by Congress upon these scientific bureaus, we can not escape the requirements of economic law, which is never a dead letter, although too often unread. If in the world of private business the competitive system sometimes breaks down and fails to protect the public, so in our narrower circle of public business there may be a similar failure of competition to produce the best results. The question is always fair and is sometimes pertinent: "How far should these Government scientific bureaus go in seeking to enlarge their fields of usefulness?" Does this competitive spirit by its appeal to individual ambitions make for better public service? To what extent is it good public policy to have the public servants on the qui vive for new opportunities to serve, new worlds to discover, new appropriations to get? Service and discovery are the proper ideals of the individual investigator, but should even ideals justify trespass and disregard of others?

First of all, we must agree that however great its advantage as a method of stimulating progress, competition should always be fair. If we are to apply the principles of the Sherman Act and the Clayton law to public business, unfair methods must be ruled out as illegal. I do not believe my comparison is a forced one. You can read decrees of the Federal courts that prohibit corporations from doing some things that are somewhat similar to practices of which we ourselves have been guilty. In one case, among other items, the defendant corporation was enjoined from making false representations concerning competitors and from hiring away employees of competitors—simply a twentieth century echo of the ninth and tenth commandments of the Mosaic law, especially the edict against coveting "thy neighbor's manservant." In the public service proper coordination of work often makes transfers from one bureau to another desirable, and so as a means of increasing efficiency such transfers are and should be welcomed, but efficiency from the larger view is attained only when the interests of both bureaus are considered, in which event the individual also profits by his larger opportunity. With science alive and expanding in so many directions, subdivision and redistribution of functions makes certain interbureau transfers of specialists absolutely necessary.

Another unfair practice, not countenanced by the courts in their regulation of private business, is tricky advertising as a method of meeting real competition. Honest advertising must be founded on truth, and even scientific bureaus may need sometimes to apply this acid test to the statements they give out to the public. Scientific investigations whose purpose is to increase human knowledge do not find their best expression in publicity whose principal object is to impress the appropriation committee. Such advertising may have its foundation in truth and yet may possess a superstructure so large and top-heavy as to violate all engineering formulas.

Unrestrained competition in the public service, then, presents some dangers no less real than those incident to unregulated competition in private business. The question must come home to every bureau chief and to his intimate advisers: "To what extent is a competitive struggle for new territory warranted, even when only fair methods are used in this endeavor for bureaucratic expansion?" I am aware that we may invoke "the public demand" and put forward other equally plausible reasons, but even if we sometimes fool Congress and on rare occasions fool each other, we never fool ourselves. Of course the individual investigator, self-centered with enthusiasm in his discovery of a new line of research, may be wholly ignorant of the fact that among the two thousand or so fellow scientists here in Washington some one in another department has already preempted that subject and possibly carried the work well on to completion; but however unconscious the scientific worker in one bureau may be of the obvious relation of that problem to the work of some other bureau, only rarely, indeed, can his own bureau chief plead any such ignorance or innocence. May I express my individual conviction that the bureau chief who makes strategic moves in this contest for enlargement of field of work is just as conscious whether he is playing the game fairly as the "captain of industry" whom we have thought ought to be investigated by the Department of Justice?

Even at its best, however, this competitive system is wasteful. The public has too often found that competition as the safety valve of business costs too much in steam. If in the branch of public business in which we are engaged the ideal is to render the best service at the lowest cost, must there not be regulation, and regulation which recognizes that there are what we may term "natural monopolies" in the Government scientific service? The monopolistic idea must here yield the same real savings to society that have come with the recent growth of public-utility monopolies. The product of our scientific bureaus is not a staple commodity but a special service to the public, and under governmental auspices this service is offered without price, yet that does not mean that we are any less vitally interested in costs. If monopoly will enable these scientific bureaus to render the best service at the lowest cost, the competitive system in scientific work should go to the scrap heap as out of date.

The adoption of the monopoly system, however, involves here, as in the field of public utilities, the correlative idea of adequate regulation in the public interest. And here is where we may be in danger of losing our way, for the question of course obtrudes itself: "Who is the guide; who is to define the field of work to be monopolized by this or that bureau?" My own belief is that Congress can not be expected to enforce even its own wishes in the matter. Some years ago the chairman of a congressional committee that had made a most thorough investigation of one of the departments, himself a trial lawyer of large experience, admitted to me that the investigation had been largely in vain; in his own words, "I know the department is full of duplication, but it would take a trained scientist to put his finger on it all." Nor can the Cabinet officer be expected in a few years to discover all the overlaps in his own department, much less to learn the logical and proper coordination of the scientific work in several departments. Thus, the responsibility in large measure falls back upon the bureaus themselves; they must provide that careful coordination which precludes wasteful competition and promotes helpful cooperation. To return for a moment to my text, I do not know that the successful coordination of the work of our two Surveys has been due in any large degree to the influence of Congress, although my experience is that appropriation committees do watch these details; nor have I ever known any Secretary of the Interior or of the Treasury or of Commerce to define this wise policy; the happy result must be credited rather to a small group of administrative chiefs in each of these two scientific bureaus.

The obligation for the proper conduct of the scientific work of the Government, therefore, can not be lifted from the shoulders of the bureau chiefs and their immediate associates in the work of administration. Moreover, this responsibility is a double one; we should feel not only the duty as public servants to avoid wasteful use of the public money, but also the obligation as scientists to conserve scientific effort by preventing duplication in research and in publication. Aside from the absurdity that lies in the spectacle of bureau chiefs trying to impress congressional committees, do we not by our acts suggest a lack of faith in science itself? We talk impressively of the day of highly specialized science and then go out and poach on what is properly the domain of others. Since the days of Aristotle students of politics have recognized as a weakness in democracies the habit of not appreciating the value of trained specialists. Within a few weeks the London Financial News remarked editorially upon the national neglect of science to which is now attributed the bulk of the British failures under the test of war. But as self-labeled scientists are we not ourselves similarly lacking in our appreciation of the value of science and of scientific organization in so far as we fail to recognize that by reason of its experience and its personnel some other bureau, even in another department, can better handle a certain subject than our own bureau?

Especially when a new idea is before the public are we apt to be temporarily blinded by its popularity and thus lose sight of the eternal fitness of things. I can best illustrate this by mention of a current topic. The fixation of nitrogen is a matter of national importance; plainly the military departments are most concerned by reason of their need of nitric acid for munitions, yet as against any claims of the War and Navy Departments must be set the fact that nitrogen is one of the essential elements in fertilizers, and its production is therefore of vital concern to the Department of Agriculture; however, the mineral deposits necessary to the fixation process are to a large extent under the jurisdiction of the Department of the Interior, not to mention some of the most available power sites; nor must I overlook the fact that this subject was first investigated and reported upon by a bureau in the Department of Commerce. So the competitive contest is on, but the obviously most reasonable consideration is still in the background. What department or bureau, if any, has already on its rolls the force of hydraulic and construction engineers ready to begin the preliminary studies and surveys and the organization already adapted to push the construction of the plant, should Congress authorize this innovation in governmental activity? As evidence of my good faith in mentioning this illustration, let me add that an investigative bureau like the Geological Survey is not organized on a plan at all adapted to the construction and operation of an industrial plant; and all that I may claim for our bureau in this connection is that we sometimes recognize the obvious.

Those of us who have been responsible for the work of securing the needed appropriations are at times likely to have our judgment warped by what we think are the exigencies of the case. A member of a scientific bureau was once so concerned for the success of his bureau that he even recommended its transfer to another department so as to get under the wing of a more generous appropriation committee. The logic of the situation does not always appeal to us, and we are willing for the moment to sell our birthright for a larger appropriation. The obvious fact in this matter of the interrelations of the scientific bureaus of the Government is that if the bureau chiefs do not always exhibit an appreciation of the proprieties in scientific investigation nor seem to possess much idea of perspective in the alignment of boundaries, can even the most experienced legislators be expected to make the best distribution of scientific work?

The possession by any bureau of even a skeleton organization of efficient specialists in a certain field would seem to be the practically unanswerable argument for entrusting to that bureau any new and enlarged work in that field whenever Congress deems larger appropriations advisable. That is the type of practical logic that is recognized in private business, for under public regulation of natural monopoly the public-utility company that first enters the local field is recognized and even protected by the public-service commission, as long as the service rendered is at all adequate. In the business world the day of preferment of special applicants in the granting of municipal franchises has passed, and in our Government business there is no better reason for granting special privileges to overzealous bureau chiefs. I sometimes think that the bureau chief comes nearer being safe and sane in his public acts and utterances in the intervals between sessions of Congress.

In this informal comparison of the actual and the ideal in the administration of the scientific bureaus of the Government I have had ever in mind the existence of a real basis for optimism in the splendid record of the Coast and Geodetic Survey and the Geological Survey in absolutely coordinating their endeavors in the public service. And I desire simply to add that this practical cooperation has been so easily accomplished that it is only as we review these several decades of joint work and estimate the value of the reciprocal services rendered that we realize how ideal have been the relations between the two Surveys.

EVENING SESSION, APRIL 5, 1916

Mr. JONES: Ladies and gentlemen, it is a pleasure to see so many of you here this evening. I hope that most of you were fortunate enough to have been present this afternoon. For the benefit of those who were not, I wish to say that the addresses delivered were most interesting and enlightening, and they served to show what a great part the United States Coast and Geodetic Survey has taken in the development of the scientific and practical interests of the Federal Government; and also the fact that the scientific branches of our Government are very closely affiliated.

We shall continue our exercises to-night by going over the history of the Coast and Geodetic Survey in its other various phases during the past century. The first address we shall hear is "The United States Coast and Geodetic Survey's Part in the Development of Commerce." We are fortunate in having with us one who has studied this question for many years, and through whose interest the Coast and Geodetic Survey has benefited materially. Our work along the coastal waters has been helped by him, and thus the protection of human life and commerce has been made surer. I take pleasure in introducing to you the Honorable J. Hampton Moore, Member of the House of Representatives.

THE UNITED STATES COAST AND GEODETIC SURVEY'S PART IN THE DEVELOPMENT OF COMMERCE

Representative MOORE: Mr. Superintendent, ladies, and gentlemen, if I had my way I would discard these notes and talk to you direct. I am interested in chart making because I have had a great deal to do with charts since the beginning of my congressional career. My constituents have found them very useful and if they were not accurate their imperfections would be very promptly brought to my notice. Which reminds me of a Delaware River story, wherein a marine reporter and the captain of a three-masted schooner, laden with lumber and destined for Philadelphia, were the principal figures. The reporter had boarded the schooner down the river, but found the captain swearing. "Where do you hail from and what is your cargo?" said the reporter. "None of your business," swore the captain. "This is the blankety blankedest river on the face of the earth." "What is the trouble with the river?" queried the reporter. "Channel changing all the way up," yelled the captain. "Let me look at your chart," said the reporter. "See for yourself," said the captain. "I do," said the reporter; "this is the chart of the Chesapeake Bay."

In this instance you will observe the fault was with the navigator and not with the chart. I know it is not customary for Members of the House—and some of them are in the audience to-night—to worry about speeches, and I would not think of putting mine in writing if it were not for the scrutinizing oversight of your superintendent and the expert technical oratory of my friend, General Black, Chief of the United States Army Engineers, and of my other friends, Commissioner Putnam, of the Bureau of Lighthouses, and Mr. Littlehales, Chief of the Hydrographic Office, who grace this platform. It is my respect for them and their expert knowledge which induces me to avoid the risk of extemporaneous speeching. [Reading:]

SUBSTANTIAL PREPAREDNESS.

Some day this great country of ours, which talks much of preparedness and does little to prepare, will wake up to the necessity of giving substantial support to the bases of our domestic progress in order that they may be better able to prepare us to maintain ourselves in our foreign relations. The country will some day realize that if we are to spend money for preparedness we must encourage the media through which the revenue is raised. We can not forever tax the people for preparedness or for any other governmental purpose without giving the people an opportunity to earn what they have to pay. The importance of a helpful governmental interest in the means of production by which the people are supported is, therefore, apparent. A prosperous and patriotic people is the basis upon which all preparedness must rest. Only in recent years have we begun to realize the real value of governmental encouragement in the development of our domestic opportunities. From the beginning of the Government we have provided for the Army and the Navy, for diplomatic relations with foreign nations, and for the administration of law within our own borders, but not until the days of Abraham Lincoln did we give any direct Federal consideration to the development of agriculture, which, with commerce and manufactures, constitute the wealth-creating and tax-bearing agencies of the Government. It was not until 1903 that commerce and the industries which enter into it were given recognition at the Cabinet table of the Nation.

And yet our forefathers had great foresight as to the import of our commercial development. They catered to it in the Constitution of the United States when they delegated to Congress the power "to provide for the common defense and general welfare of the United States"; "to regulate commerce with foreign nations, and among the several States, and with the Indian tribes," and also "to establish post roads," which in the days anterior to the railroads were carriers of the mails as well of commerce by land and water. The framers of the Constitution dealt in their time with a population approximating 4,000,000 people, but they were shrewd enough to perceive that the country would expand, and that commerce would increase, and in due course would come under the regulation of law. At the time they announced the Constitution in September, 1787, however, an extensive international commerce had already been developed. It was carried in American ships, which did profitable business, though at great risk, in all the seas of the world. It was the active operation of these ships and the importance of American interchange with other nations that induced Thomas Jefferson to suggest the establishment of a Coast Survey to chart our coast and otherwise provide for the encouragement and safety of American shipping. Congress was a laggard in those days, even more than it is accused of being now, and it was not until 1816, after the close of the War of 1812, that field operations were undertaken by this new arm of the Government service. We are celebrating the one hundredth anniversary of this event to-night, and I am not exceeding the bounds of truth or propriety when I venture the assertion that the celebration is timely and justifiable, since so little is known by our more than 100,000,000 population of the direct benefits which this service is constantly rendering to life and trade.

Organized originally as a bureau of the Treasury Department, continuing under the rigorous methods of the Army and Navy, and now under the purely civil jurisdiction of the newly created Department of Commerce, the Coast and Geodetic Survey pursues its prosaic work of discovering new water routes, charting new regions, and recharting old ones, in a manner that invokes our highest admiration. Loss of vessels along the Atlantic seaboard and on our inland waters was not infrequent when the Survey was organized 100 years ago, but the draft of vessels and the depth of channels were far different then from what they are to-day. In the beginning it was sufficient to make surveys and point out the marine menaces to vessels of so shallow a draft as 12 feet; to-day it is necessary to extend the Survey over inland waters and across tempestuous seas upon which vessels drawing as much as 38 feet must have leeway for maneuvers. It is not difficult, therefore, for those who entertain a right appreciation of faithful Federal service to understand the extent of the hardships and privations that must be endured by the men who in fair weather or in foul, in daylight or in darkness, must mark the channels and point out the impediments to navigation in our rivers and harbors and upon the high seas. Like the Lighthouse Service, or the Coast Guard, which we formerly knew as the Revenue-Cutter and Life-Saving Services, the Coast and Geodetic Survey is constantly on duty at the frontier, where it is essential to preserve and safeguard the life and property of our people. I have been assigned to speak upon "The United States Coast and Geodetic Survey's Part in the Development of Commerce." I can not respond more happily than to say that the Coast and Geodetic Survey is an arm of the Federal service that is indispensable both to the Government and to commerce. It is made up of as faithful and devoted a body of public servants as may be found anywhere under the Stars and Stripes.

In the midst of our national prosperity and more particularly since we have come to discuss the preparedness of this Nation to maintain its honor in peace or at war, I have wondered whether the Government and the people who support it have fully appreciated the part which the Coast and Geodetic Survey has played in our commercial development. I have wondered whether the business man who has been a great beneficiary of this service has thoroughly understood the work and the needs of this important bureau. We know how easy it is to criticize the work of public servants and how unusual it is to properly and justly appraise their services, but here we have a bureau unmixed with political conditions, sharing the perils which beset the Army and Navy but never aspiring to the spotlight. Even Congress, I sometimes think, unduly stints itself in its appreciation of this important branch of the public service. When we go for appropriations which lay hard upon the program of distribution we do not always see these silent sea plotters sounding with the lead off the rocky coast of Maine, or hauling the wire drag in the icy waters of Alaska. Their persistence and even their heroism pales into insignificance when it comes to the adjustment of the dollars and cents. It is one of the misfortunes of the men whose hearts and hopes are wrapped up in achievement that the headlines are reserved for others; yet the proofs of their usefulness are so convincing as to bring to them at least the consciousness of duty well performed. As to these services I hope to group some facts and figures that may be of interest.

Vast as has been our national growth, and important as it is that our water routes shall be made safe for transportation, it is regrettable that the facilities of the Coast and Geodetic Survey, both as to men and means, have not been increased in proportion to the work that is to be done. There is a strange misunderstanding in the public mind as to the need of appropriations for rivers and harbors. It is said that appropriations once made for improvements, or for maintenance, should be sufficient, and an outcry is raised when Congress is asked to provide for the maintenance of a channel that was dredged last year, as if a channel once dredged would forever maintain itself. It is unfortunate that this sort of reasoning should sometimes be indulged with respect to the Coast and Geodetic Survey, as if a chart of a sandy shore made a decade ago would be safe and serviceable for the mariner of to-day. With the old type sailing vessel giving way to the steamer and dreadnaught, with the modern barge taking the place of the antiquated canal boat, how absurd is the thought that the ancient condition will suffice for the modern or that nature will lay supine at the foot of man. There is no body of men more capable of dealing with the forces of nature than the United States Army engineers, and yet I doubt that any of them, efficient and capable as they are, would undertake to guarantee that the forces of nature in 1920 will not sweep down the most expensive but unsupported jetties of 1916. It is inevitable that new shoals will form and that new obstructions to navigation will be discovered, as it is inevitable that artificial channels in tidal streams will not forever maintain themselves.

What the Coast and Geodetic Survey undertakes to do for commerce is to keep commerce informed as to hydrographic conditions. It surveys the waters, it marks upon a chart the underlying conditions, it points the mariner to the lanes of travel that are safe, it warns him so far as it is able to do of the rocks and the shoals that may bring him to grief. When I speak of a lack of public appreciation of the invaluable service thus performed, I rely upon the facts as they are revealed by study of our geographical conditions. Who stops to think of the extent of the coast line of the United States? Coupled with that of Alaska, it exceeds 10,000 miles. All this is supposed to be traversed by the men who explore our waters for the sake of commerce. Think of the rocks and the shoals that abound in so extended an area, reaching miles out from the coast into the sea, and we have the first glimpse of the magnitude of the work. Add to this 10,000 miles of coast line the actual shore line, including all the islands, bays, sounds, and rivers in the littoral or tidal belt, and we bring into the jurisdiction of the Coast and Geodetic Survey for investigation and exploration, for sounding by lead and dragging by wire, no less than 91,000 miles. But the work of the bureau does not stop with its oversight of the shore lines of continental United States and Alaska. It embraces the shore lines of Porto Rico, Guam, Tutuila, the Hawaiian Islands, and the Philippine Islands, whose general shore line exceeds 6,300 miles and whose detailed coast line is in excess of 13,000 miles. Since the commerce of the United States, greater within the United States than outside of it, penetrates to every part of this country, to all our islands and possessions and to every nation of the world, it is easy to understand how tremendously important it is that our coast charts should be accurate and up to date.

In discussing the relation of the Coast and Geodetic Survey to that commerce which avails itself of transportation by water, the element of human life is not to be overlooked. It is bad enough that valuable property in ships and cargo shall go to destruction upon uncharted rocks, but it is always deplorable that human life should thus be lost, and yet each great storm on any of our coasts brings its chapter of accidents. The wreck of the revenue cutter *Tahoma* on an uncharted reef in Alaskan waters is easily recalled. The captain and men drifted about in open boats and were finally rescued, but the valuable property of the Government was lost. The crash of the *Titanic* against a berg in the waters of the Atlantic and the loss of hundreds of lives is still fresh in the minds of the reading public. These and hundreds of other tragedies of the sea contribute to the annual toll which is paid for a lack of sufficient information as to hidden dangers. It is possible that many of these accidents would have occurred in spite of any survey, and yet it can not be denied that the incompleteness of the survey of the American coast is responsible for many of them. I shall give some facts with respect to the work that is yet to be done, especially as it pertains to some of the more frequented watercourses along the Atlantic coast, but before doing so I wish to refer, in the interest of commerce, and as evidencing the safety of navigation by reason of such service as we now have, to figures showing the number of passengers carried on the vessels of the United States which are obliged to report to the Supervising Inspector General of the Steamboat-Inspection Service. I wish all those who give little attention to the life-saving functions of the Government and who are sometimes lead into violent criticisms of public service through headlines describing the horrors of exceptional accidents might peruse these figures. For the fiscal year ended June 30, 1915, the number of passengers carried on steam vessels obliged to report to the Steamboat-Inspection Service, and these were not all the water-borne passengers by any means, was 307,348,008. Dividing this number by 107, the total number of passengers lost, it is shown that only one passenger was lost for 2,872,411 passengers carried. The total number of lives lost from all causes, including passengers and crew, was 368.

Wherever there is commerce human life may also be expected to abide. It is not unfair, therefore, in discussing the relation of commerce to the Coast and Geodetic Survey to introduce this human-life feature. But if we were to ignore it altogether, the commerce side of the question is formidable enough. We can even afford to eliminate the Government's own interest, including naval vessels and the fleets of the various departments, including that of the Army, which, although it is not generally known, includes about 2,500 vessels. All these have to do with the work of the Coast and Geodetic Survey, for it would be a foolish captain, indeed, who ventured upon any of the seas, or upon any of our navigable inland waters, for that matter, without a chart. But my purpose now is to introduce the commercial statistics so far as I have been able to assemble them as they relate to water-borne transportation. I am unable to give the figures with respect to our coastwise trade, as for some unaccountable reason Congress has never made any appropriation to enable us to obtain statistics as to the business done along the Atlantic seaboard. I presume the same condition prevails with respect to trade on our other coasts. The Secretary of Commerce has sought to obtain appropriations for this purpose, but they have not been granted to him. It is a fair presumption, however, that our coastwise trade in tonnage and value is not far below that of our foreign trade. However, this is but a guess. We have haphazard statistics brought up through commercial bodies which are not wholly reliable. We can tell something about our losses, however, which though they constitute a small percentage of the entire commerce of the coast are an indication of its magnitude. A voluntary board of experts a few years ago reported to the Atlantic Deeper Waterways Association that in 10 years from 1900 to 1909, inclusive, there had been no less than 5,700 disasters to shipping along the Atlantic seaboard, involving the loss of 2,200 lives and the destruction of more than $40,000,000 worth of property. If these figures may be relied upon, and they were taken principally from the life-saving statistics, it is to be inferred that the volume of trade along the Atlantic seaboard for which we have no official statistics is enormous. The Coast and Geodetic Survey is to be given credit for the safe conduct of a very large proportion of that commerce.

We are more fortunate with regard to statistics in our foreign trade, all of which, of course, passes from or returns to the United States through charted waterways. A perusal of these figures is illuminating. They throw much light upon mooted questions with respect to tonnage and values in geographical divisions of the United States, but they serve to emphasize the value of the service to commerce of the governmental agency which we have been extolling. I intend to present as a part of this address an official statement by the Department of Commerce of the number and net tonnage of sailing and steam vessels entered and cleared in the foreign trade of the United States during the fiscal year ended June 30, 1914, but for convenience shall summarize the totals. Our greatest foreign trade, tonnage, and values considered, is along the Atlantic seaboard, but including the Pacific, the Gulf, and the Great Lakes, the number of vessels coming and going during the year referred to was 80,667. Their net tonnage aggregated 106,571,986, and the total value of their cargoes was $3,785,468,512. The detailed statement is as follows:

Number and Net Tonnage of Sailing and Steam Vessels Entered and Cleared in the Foreign Trade of the United States during the Fiscal Year Ended June 30, 1914

[By geographic divisions]

Geographic divisions.	Entered.		Cleared.		Total entered and cleared.	
	Vessels.	Net tons.	Vessels.	Net tons.	Vessels.	Net tons.
Atlantic	10,489	26,401,314	10,084	25,491,836	20,573	51,893,150
Pacific	5,319	6,042,347	5,236	5,798,238	10,555	11,840,585
Gulf	4,697	7,608,628	4,986	8,453,138	9,683	16,061,766
Great Lakes	20,512	13,336,288	19,344	13,440,197	39,856	26,776,485
Total	41,017	53,388,577	39,650	53,183,409	80,667	106,571,986

Total Values of Imports and Exports into and from the United States during the Fiscal Year ended June 30, 1914

[By mode of transportation and geographic divisions]

Geographic divisions.	Imports.	Exports.	Total imports and exports.
Water borne:			
Atlantic	$1,360,519,398	$1,299,062,457	$2,659,581,855
Pacific	130,767,796	125,991,894	256,759,690
Gulf	120,983,430	570,139,028	691,122,458
Great Lakes	104,996,047	52,565,775	157,561,822
Interior	20,441,982	705	20,442,687
Total water borne	1,737,708,653	2,047,759,859	3,785,468,512
In cars and other land vehicles	156,217,004	316,819,289	473,036,293
Grand total	1,893,925,657	2,364,579,148	4,258,504,805

Note.—The above tables cover only the commerce of the United States with foreign countries. No data are available for the domestic coastwise commerce.

These figures relating to foreign and domestic commerce and to the life-saving features of our aids to navigation speak eloquently for themselves. It is to be regretted, however, that they do not speak loud enough to be heard by those beneficiaries in commerce whose interest in a continuance of the service might assist in procuring for it that congressional recognition which it deserves. The men of commerce, if they would only stop long enough to consider the needs of the service, could speak more eloquently upon this subject than the tireless workers who heave the lead and draw the wire drags.

In the presence of scientists and explorers, professors of universities, and picked men of the Army and Navy, I have no desire to attempt a discussion of the technical phases of the Coast and Geodetic Survey's service. I am fairly familiar with them, however, for all practical purposes, and that I take it is about equal to the average information possessed by the millions of passengers who sail upon the steamboats, and the thousands of merchants and traders who busy themselves with the commerce that seeks the markets of the world. I know what it means for a vessel to run upon the sands. I have not been upon one that struck a rock, but I can understand that the sensation would not be an altogether pleasant one. If I were the captain of a merchant vessel, I would not desire to face the owners if the ship intrusted to my care had run upon a bar that was not marked in antiquated charts. If I were captain of a naval vessel under like circumstances, I would expect to be court-martialed. I think all of us, scientists or laymen, understand the significance of bringing a ship to grief. It is not beyond the range of possibility, however, that a new captain with an old chart, or a smart captain without any chart at all, may find that the shifting sands have made impassable the course he ran when he made his former voyage. It is not improbable that venturing into new territory he may run upon the point of a pinnacle rock which he did not know was there. All these things have actually occurred to captains of merchant vessels, and even to officers of the highest skill in the Navy. It is because these things have happened and because they are bound to happen so long as the winds blow and the tides ebb and flow that the work of the Coast and Geodetic Survey must be supported and extended. We can not adequately survey a coast line of 10,000 miles with men and equipment for 5,000 miles. We can not increase the area over which the force must operate without increasing the force. We can not successfully survey the Philippine Islands and our other island possessions and continue effectively the work along the shore lines of continental United States without neglecting a part of the work in one place or the other, and yet it is evident so long as nature continues to roll the ocean's waves against the sandy shores and the rock-bound coasts of this country a scrutiny upon the changes wrought by nature must be made as constantly as nature itself performs. Let me illustrate by comparing the work that is now going on in Alaska with the work along the lower regions of the Mississippi River. The Coast and Geodetic Survey has recently made a relocation of the Kuskokwim River, which empties into the Bering Sea. Commerce is picking its way along that river into the slowly developing Alaskan territory, but it required men and vessels to do this work, and they had to be drawn from other sections of the country. The Kuskokwim River, wonderful stream that it is, is only an insignificant part of the work that is waiting the surveyors in Alaskan waters. The pinnacle rock abounds in this territory and left uncharted threatens the vessels which attempt to invade it, but the surveyors have only begun their work in Alaska; meanwhile, there is need for additional surveying at the Gulf approaches to the Mississippi. The commerce in that vicinity warrants a careful and accurate survey, and yet we are informed that by virtue of nature's constant changes along our coast line the original depth of 10 fathoms of water off Southeast Pass of the Mississippi River have shoaled up to a few feet. When the commercial public grows tired of denouncing pork-barrel appropriations for rivers and harbors, it may find food for serious thought in the proposition that commerce is more interested in the maintenance of channels than are the overworked engineers of the United States Army, who stand a good deal of unwarranted abuse for following the instructions of Congress to keep the channels of commerce in good order.

If in this closing chapter I am accused of being prejudiced in favor of the Atlantic seaboard, let it be recalled that the statistics show that the greatest commerce, foreign and domestic, traverses that coast. I am interested in the safety of life and commerce upon all our coasts, but by reason of familiarity with the Atlantic coast I may be pardoned for calling attention to a few of our needs. Suppose some day, as many experts think probable, the Caribbean Sea should become the base of a

44282°—16——5

great naval warfare. Florida undoubtedly would be something of a center of American activities. Her inland waterways, so far as they are fit, would be serviceable for supply and munition ships, and for small vessels of the Navy. We can not count too much on these waterways, however, for they have not been improved as they might have been. But what layman ever knew, or knows now, that the Coast and Geodetic Survey does not think its work complete on all sides of the Florida coast until it has done 72,000 square miles of hydrographic surveying. Our needs by way of protection against reefs and shoals around the Florida coast are far more extensive than they are in the Alaskan waters, and yet in Alaska but 8 per cent of the navigable waters have been surveyed to the satisfaction of the Bureau. The dangers of Cape Hatteras are known to every American, and the currents that abound in that vicinity demand the frequent inspection and oversight of the chart makers. Just above Hatteras along the North Carolina coast the shore line is constantly changing, as is well known to mariners. Inlets close and open according to the whims of nature. It is an interesting historical fact that no living man is now able to locate the inlet through which passed the Sir Walter Raleigh expedition, which made the first English settlement on Roanoke Island. That the vessels of Amidas and Barlow entered Croatan Sound is a well-established fact, but the inlet through which they came has long since disappeared. The closing of inlets as far north as New York has not been of infrequent occurrence in the course of the last century, nor has the accretion or recession of land where the waves and storms have played upon it. Near Chincoteague Inlet, Virginia, is a comparatively new harbor, known as the Assateague Anchorage. It owes its existence to a natural change in the coast line at the south end of Assateague Island, which has converted an exposed bight into a well-protected and much-frequented harbor. This harbor is preferred by local shipping to some of the artificial harbors of refuge along the coast. It has an added importance because it is the only harbor between the entrances to the Chesapeake and Delaware Bays, but it must be examined frequently in order that the shifting sands may be so charted as not to deceive the mariner. Advancing along the coast to the New Jersey and Delaware shores, where the shipping is more conspicuous, it is worth mentioning that at the present time the Coast and Geodetic Survey stands in need of funds to survey and resurvey about 13,000 square miles offshore. There are shoals constantly forming on these shores which should be examined and charted in the interest of navigation. This is territory which is presumed to have passed the pioneer stage, but it evinces that same disposition to conform to the forces of nature that prevail in less frequented waters. More remarkable than this, however, is the situation with respect to the waters approaching the great metropolis of New York. The rivers and harbors bill now pending in the House of Representatives carries an appropriation of $700,000 to extend and deepen the channel from the sea to the Brooklyn Navy Yard, a very important work that should have been attended to long ago. The reason for this appropriation is that there are obstructions in the channel, possibly of rock formation, which make navigation perilous for the dreadnaughts of the Navy. When vessels of 12 feet draft were sailing into New York Harbor it made no difference about this channel, but the increase in the size and draft of vessels has made a difference, and the lead and the drag must be put in use again. There are rocks in the East River, as everyone knows, some of which are of the pinnacle type, and strange as it may seem they have only recently been located. As late as 1915 the wire drag was used by the Coast and Geodetic Survey in the East River, locating certain dangerous shoals which are a menace to navigation and which in the event of war would seriously handicap our battleships. If commercial New York, exposed as it is to the guns of a hostile fleet, is still making discoveries of dangerous formations and obstructions in its waterways, it is high time that the people elsewhere along our coast lines should wake up to the importance of increasing and developing the Coast and Geodetic Service. I have not time to further discuss the work along the Atlantic coast except to say that the Maine coast abounds in rocks and shoals and the wire-drag service is badly needed there, as it is all along the New England coast. The report of a recent survey in the vicinity of the Rockland naval trial course discovered no less than four shoals on any one of which a battleship might have been seriously damaged. It is noteworthy also that in a survey to the approaches to Narragansett Bay, of which we are proud to boast as one of the most beautiful sheets of water along the seaboard, evidences of hidden formations were discovered. Only two years ago the wire-drag party discovered no less than 50 shoals at the entrance to Buzzards Bay, which is coming into prominence because of the newly constructed Cape Cod Canal, and that is getting close to home.

Ladies and gentlemen, I join with you in celebrating the hundredth anniversary of the Coast and Geodetic Survey. It has had a long and useful career. It has been less appreciated than it deserves. Its work is not finished; it never will be. So long as the winds and tidal currents exist, so long as the waters of the ocean beat upon our shores, so long as the waterways and canals of the interior are capable of bearing the burden of commerce, just so long will the work of the Coast and Geodetic Survey be necessary for the promotion of trade and the preservation of life and property, and just so long should it be generously and amply supported by a grateful people.

Mr. Jones: I know we are very thankful to Representative Moore for telling us so vividly of the great practical value of the Coast and Geodetic Survey in further protecting the waters and harbors of our great coast.

West Point is the oldest engineering school in the United States. Its cadets are trained there not only to be military men but engineers also. The Corps of Engineers of the Army is charged with the charting of the Great Lakes, with the development of our harbors, and also with the control and improvement of the great streams of our vast territory. The engineers of the Coast and Geodetic Survey have been closely and intimately associated for the past century with that great organization. We are honored to-night by having with us one eminently fitted to tell of its great work in relation to that of the United States Coast and Geodetic Survey, and I take pleasure in presenting to you General W. M. Black, Chief of Engineers of the United States Army.

THE UNITED STATES CORPS OF ENGINEERS AND ITS RELATION TO THE UNITED STATES COAST AND GEODETIC SURVEY

General BLACK: Mr. Superintendent, ladies, and gentlemen, it gives me great pleasure to be permitted in this centennial celebration to speak of the work and of the association in work of the Corps of Engineers and the United States Coast and Geodetic Survey, two bodies of public servants the record of whose achievements in scientific research and in the faithful performance of work for the public welfare must ever form a bright page in our country's history. This association began with the organization of the Coast and Geodetic Survey.

The Corps of Engineers was organized as a separate body in 1802 and of it the United States Military Academy formed a part. The first Superintendent of the Coast and Geodetic Survey was appointed from the staff of instructors of the Academy—Ferdinand R. Hassler. He served at the Academy as acting professor of mathematics from 1807 until 1810. Professor Hassler had made a reputation of note as surveyor in his native Switzerland before leaving there in 1805. When the necessity for the better mapping of our coasts was impressed upon President Jefferson, he selected Professor Hassler to take charge, though it was not until 1816 that the work of the Coast Survey actually started. About a year later the work was discontinued, though the survey of the coasts was carried on thereafter by officers of Engineers and of the Navy until the Bureau resumed its operations under Superintendent Hassler in 1832.

Among the Engineer officers on duty on survey work prior to 1832 was John J. Abert, who as major and lieutenant colonel was engaged in many surveys of the coast from 1816 to 1827.

In addition, for several years, beginning in 1818, the international boundary surveys required under the treaty of Ghent were carried on along the northern boundaries of New York, Vermont, New Hampshire, and Maine. Second Lieutenant Delafield, Captain Partridge, and Professor Ellicott, of the Corps of Engineers, and Professor Hassler, of the Coast and Geodetic Survey, were engaged in the work.

When in 1843 it was deemed necessary to reorganize the Coast Survey, again the Corps of Engineers lent its aid. On the recommendation of the principal national scientific societies, Alexander Dallas Bache, a graduate of the Military Academy of 1825 and during his period of service in the Army an officer of the Corps of Engineers, was appointed Superintendent and he remained the head of the Survey until his death in 1867.

In announcing his death the Secretary of the Treasury used these words:

> No man within the present generation was more widely known in the walks of practical science; none has been so closely identified with collateral service in the various public departments. Under his direction that great work (the Coast Survey) has been eminent no less for its abundant results than for its high scientific character, which won the approbation of the leading learned bodies of the world, among whom his name has been held in honor.

From 1843 through a period of many years officers of both the Army and Navy served by detail with the Coast Survey Bureau. Thus we find Captain A. A. Humphreys, corps of topographic engineers, served as assistant in charge of the Coast Survey office at Washington from 1844 to 1849 and on surveys in the field during 1849 and 1850; Captain Thomas J. Cram, corps of topographic engineers, served as assistant in the Geodetic Survey of the coast of New England from 1847 to 1855 and of the coast of North Carolina from 1858 to 1861; Isaac I. Stevens, first lieutenant and brevet major, Corps of Engineers, was assistant in charge of the Coast Survey office in Washington from 1849 to 1853; Captain H. W. Benham, Corps of Engineers, held the same position from 1853 to 1856; and Lieutenant William P. Trowbridge, Corps of Engineers, was on duty with the Coast Survey from 1851 to 1856, and after his resignation from the Army was an assistant in the Coast Survey from 1857 to 1861. It may be interesting to note also that the zenith telescope, with which the most reliable determinations of latitude are made, was the invention of Captain Andrew Talcott, of the Corps of Engineers. Similarly, the wire drag or sweep used for locating subsurface obstructions, where large areas must be covered, was first devised and used by the Corps of Engineers. This record shows how directly the Corps of Engineers has been interested in the work itself of the Coast and Geodetic Survey.

During the past half century the two services have had few opportunities to associate in the same work, the last which I now recall having been the Mexican boundary survey between 1890 and 1895, conducted by a commission in which the Corps of Engineers and the Coast and Geodetic Survey were represented and the Mississippi River Commission on which the two organizations have representatives.

But the association of the two organizations does not end with this. Their work is mutually helpful.

When a tidal harbor is to be improved the first recourse of the Army engineer is to the maps of the Coast and Geodetic Survey. The latest are studied to show existing dangers. Then these are compared with earlier issues to mark the changes which have occurred, and by a study of these changes to discover a probable cause for existing shoals and a course of action which will lead to a permanent improvement. The tide tables are studied for tidal ranges and periodicity. Finally, when the detailed investigations and surveys are to be made to determine the nature and cost of the work required, again recourse is had, if possible, to the record of permanent triangulation stations established by the Bureau and of their positions relative to the work.

Then the aid of the generally honest but usually uninformed citizen is frequently apparent. Some years ago I was making a study for the improvement of a certain reach of the St. Johns River, Florida. A survey of the reach had been made and I wished to compare it with the Coast and Geodetic Survey map of the same reach made some years before. Unfortunately the changes of shore line had been too great to make an accurate comparison of the maps easy, but the records showed that the Bureau had laid out and monumented a base line at a point on shore. So the survey party landed to tie these older monuments into the later triangulation system. One monument was readily found, but the other, at a known distance and in a known direction, could not be discovered. After a search had been conducted for some time a native who had watched the work in an interested way inquired what was wanted. On being told, he said, "Oh, I will show you where that stone is. It's right over there among those trees. I wanted a stone for my wife's grave and put it there. You can take it again if you want it."

So all along our coast the general information gathered by the Coast and Geodetic Survey is used and when necessary is extended by local surveys by the Corps of Engineers. Free interchange of information is made between the organizations, and the survey work of one supplements the work of the other. By standing regulations, whenever in the course of an improvement a new map is made by the Engineers, a copy must be supplied to the Coast and Geodetic Survey and is used by that Bureau to revise earlier editions of its own charts. Similarly, when tidal currents or tidal ranges are to be considered and studied, an interchange of observations is made. Sometimes, as I have found to my own discomfiture, the united studies of both bodies fail to supply a solution to the problem. This only shows that neither body knows it all and that much remains to be learned before it can be said that the mighty forces of the ocean, with which both organizations deal, are thoroughly understood.

In a recent examination of the East River, New York, it became necessary to study the tidal ranges and tidal currents in order to determine, if possible, what would be the effect of certain proposed works. Again recourse was had to the records of the Coast and Geodetic Survey. Between 1872 and 1878 and from 1885 to 1887 Professor Henry Mitchell had made careful studies of these currents. New observations at other sections of the river were made by the Engineers, and this work checked closely with the earlier determinations. Inasmuch as the field work for studies of this character is difficult and expensive such a check was of great value, for on the results were based recommendations for large expenditures.

The problems presented by the tidal and current movements of the ocean are complicated and difficult. Though this subject has been investigated through centuries, it can not be claimed that our knowledge is complete, and it is misleading to place too great reliance on theory.

In one of the textbooks formerly used in the celebrated French "École des Ponts et Chaussées" there is a paragraph which has always seemed to me noteworthy, both for unconscious humor and for the underlying truth involved. It is found in the description of the ocean movements. After stating the theory of the laws governing tidal and wave action, it says that a celebrated mathematician once studied out a formula from which, with proper entry of known terms, the status of the movements of the great deep could be determined for any epoch since the creation of the world, but adds that unfortunately the formula could not be integrated and even if that could have been done, the results would probably have proved wrong by reason of unknown factors.

More observations and more study are required, and required at points so separated and under conditions so different, that conclusions deduced from all may be capable of general application. The formulas of to-day must be retried and recast so that they may be useful practically.

The end to be attained by such studies is practical. One example will suffice. The Hudson River is a tidal stream for 150 miles above its mouth. In 1831 the tidal range at the limit of tidal action, the dam at Troy, was 1.09 feet. Since that date the channel of the upper river has been straightened and deepened. To-day the tidal range at Troy is about 3 feet and the plane of mean low water has been lowered. It is desired to deepen the channel farther. Until the causes which govern the height and rate of progress of the tidal wave through the various channel widths and depths traversed from the mouth to Troy are known, the exact effect of the further improvement of the channel on the range and plane of mean low water of the upper river can only be estimated, and the depth to which the dredging must be carried can be determined only approximately. Fortunately the quantity of excavation involved in the present project is not so large as to make this a matter of great moment. But should the wishes of the people of Albany and Troy be fulfilled and an attempt be made to give a depth of 25 or 30 feet as far as Troy, an error in the assumed elevation of the plane of final reference—that of mean low water after the improvement shall have been completed—might prove very costly. Studies are now being carried on with a view to disclosing the causes of the variations in the range and velocity of the tidal wave in the river below, and interesting data have been gathered, but as yet the problem is not solved.

Scientific research of this kind falls within the duties of both the Corps of Engineers and the Coast and Geodetic Survey, and the amount of study to be given seems to be limited only by the funds available for the work. Each increment gained for human knowledge is but one step in advance and the path to omniscience in any subject is too long to be measurable.

To the unthinking it might appear that once the coasts had been mapped the need for further surveys would cease. Such is not the case. The sea is both a builder and a destroyer of shores, and her labors are unceasing. Maps need constant and periodic revisions. They are eyes for the mariner and must show clearly and accurately the hidden perils below the surface. Only those experienced in this work can appreciate its difficulties and its dangers. A century of faithful effort has not sufficed for the accurate and detailed mapping of all of our coasts and the need for revision is ever recurring.

In yet another way is the work of the Coast and Geodetic Survey useful to and utilized by the Corps of Engineers of the Army. One of the duties of the latter is the formation of projects for the national defenses. In this the maps of the coast as well as the detailed description of the coasts and the harbors found in the Coast Pilots are invaluable aids. The permanent seacoast defenses are located with a view to forbidding to an enemy the use of the channels of approach to the more important harbors. The records of the Corps of Engineers show that prior to the organization of the Coast Survey an important part of the work of the Engineer officers was in surveying and mapping the water areas which would have to be covered by the fire from proposed fortifications. Further, the entire coast must be studied to determine possible landing points for a hostile expedition in order that plans may be made for such dispositions of the mobile forces as will provide for the most effective defense against such an attack.

The work of the Corps of Engineers and that of the Coast and Geodetic Survey touch at many points. The harbor surveys made by the Corps of Engineers are local and for the determination of specific questions. Those of the Coast and Geodetic Survey are those required for the information of mariners. There need be and should be no interference and no duplication of work. The best results for the Nation which both serve can be obtained from that cordial cooperation in the future which has existed in the past.

The great work done by the Coast and Geodetic Survey in its hundred years of existence and the traditions of faithful labor well performed will always be an inspiration to further effort. May the Survey continue steadfast in its work, and may it receive such substantial recognition from the Nation it has served so well as to permit the record for the coming hundred years to outshine the brilliant achievements of the century whose close we now celebrate.

Mr. Jones: I am sure it has been a pleasure for all of us to hear how two great Government bureaus have worked so closely together during the past 100 years, and we are greatly indebted to General Black for telling us so clearly of this cooperation.

The next address will be "The Lighthouse Service and Its Relation to the United States Coast and Geodetic Survey." Our nautical charts would lose much of their value if from them were omitted the objects known as "aids to navigation" that guide the navigator. The Bureau of Lighthouses plays an important part in making these charts. The Commissioner of Lighthouses spent many years as an officer of the Coast and Geodetic Survey before he assumed his present duties. He is therefore peculiarly and eminently fitted to tell us just how the two bureaus are closely affiliated. It affords me pleasure to introduce to you Mr. George R. Putnam, Commissioner of Lighthouses.

THE LIGHTHOUSE SERVICE AND ITS RELATION TO THE UNITED STATES COAST AND GEODETIC SURVEY

Mr. Putnam: Mr. Superintendent, ladies and gentlemen, I am asked this evening to speak on "The Lighthouse Service and Its Relation to the United States Coast and Geodetic Survey." When I left college I came to Washington to work for the Coast and Geodetic Survey. The Superintendent at that time was Doctor Mendenhall, whom we are all so glad to see in Washington again to-day. I do not care to mention the salary which he offered me to come here at that time. It makes me feel envious when I see the compensation given to young men coming into the Lighthouse Service and the Survey now, but I had many years of interesting work in the Coast and Geodetic Survey, and so I never regret the small compensation that I began with.

Before taking up my subject I wish to extend the congratulations of the sister bureau to the Coast and Geodetic Survey on this anniversary occasion. There are probably few bureaus of the Government whose work lies more along parallel lines than does the work of the Coast and Geodetic Survey and the Lighthouse Service. Not only does their work touch in many points, but they are contiguous in their territorial extension; and the field of each embraces in general the coast line of the United States and of the territories belonging thereto.

All progressive maritime countries have recognized their obligation to survey their coasts and to light and mark them; this is a duty not only for the benefit of their own people, but it is an international obligation of the highest character. There are instances where a Government maintains a light in a position where it is of more benefit to foreign vessels than to its own, where a considerable part of the passing shipping making use of the light is not bound to or from the ports of the country maintaining it. The light at Cape Maysi, the east point of Cuba, probably aids few vessels bound to Cuba as compared with the number of passing ships of all countries. The great flashing lights at the Straits of Dover guide numerous vessels which do not call at an English or a French port.

When a country builds a lighthouse or establishes a fog signal or publishes a chart of its coast or surveys a portion of the uncharted waters of the earth it aids the whole family of maritime nations, and such works show an international public spirit which it is so desirable should be developed.

The importance of lighthouses and other aids to navigation was recognized at the very beginning of our National Government. At the first session of the Federal Congress an act was passed, approved August 7, 1789, providing that all expenses "in the necessary support, maintenance, and repairs of all lighthouses, beacons, buoys, and public piers erected, placed, or sunk before the passing of this act, at the entrance of, or within any bay, inlet, harbor, or port of the United States, for rendering the navigation thereof easy and safe, shall be defrayed out of the Treasury of the United States." Thus, the lighthouse work was one of the earliest technical works undertaken by the General Government. Early in that century, in 1716, 200 years ago, the colony of Massachusetts had built at Boston the first lighthouse on this continent.

There were but eight lighthouses in operation within the United States when the work was taken over in 1789. From that small beginning has grown the present Lighthouse Service of this country, the most extensive lighthouse system under a single organization in the world. It maintains 14,544 aids to navigation, of which 5,155 are lights, it employs 5,792 persons, uses 113 vessels in its work, and marks the sea and lake coasts and navigable rivers of the United States and its insular and other outlying territory with the exception of the Philippines and the Canal Zone.

The lighthouses were at first directly under the charge of the Secretary of the Treasury. In 1852 the Lighthouse Board was organized, and in 1910 Congress established the present Bureau of Lighthouses.

Although charged with what seems to be a simple and practical duty, maintaining lights, fog signals, buoys and beacons to guide vessels, yet that duty has required, in order to reach the highest effectiveness, the utilization of available apparatus and the development of new apparatus of a high order. The work of the physicist, the electrician, the civil engineer, the mechanical engineer, and the naval architect have all been drawn upon in the equipment and upbuilding of the lighthouse establishment. There has been a continuous and steady advance from the time of the first lighthouse in this country. The common fish-oil lamp was early replaced by the Argand burner, and later the intensity of the light was increased by using a number of concentric wicks. Sperm oil was replaced by lard oil as an illuminant, and this by kerosene. A very marked advance was made a few years ago by the introduction of the oil-vapor lamp, greatly increasing the candlepower from a given quantity of kerosene. Electric lights are employed at some stations and light vessels, and acetylene and oil gas lights have proved valuable for certain purposes. Reflectors were early used and the Fresnel lens was introduced in this country in 1841. An important advance has been the introduction of improved apparatus, roller bearings or mercury floats, for revolving heavy lenses, as well as occulting apparatus. As a result of this nearly all the principal lights have been given distinctive characteristics. The early fog signals were only the gun and the hand bell but steady advance has since been made. Bells with mechanical strikers, trumpets, horns, steam and air whistles, sirens, diaphones, bell and whistle buoys, submarine bells, have in turn been added, and now there is prospect of the radio fog signal. The advance in buoys has been marked by larger and more prominent iron buoys, and sounding buoys, and particularly by the lighted buoys which have been so greatly improved and increased in number in recent years. The early light vessels, so often adrift and powerless, have been gradually improved up to the present full-powered lightship with flashing light and powerful fog signal. Not many years ago it was considered impracticable without frequent loss to maintain a light vessel off Cape Hatteras, and yet vessels have now been on this station almost continuously for nearly 20 years. The leading maritime countries have contributed to the steady advance in lighthouse engineering and our Service has not hesitated to draw from any source available, but a number of important advances have been made here.

The desirable distribution along a coast of lights and other aids depends on the maritime importance of the coast, on its physical character and on the prevailing meteorological conditions, and the problem varies greatly on different portions of the coast of the United States. The North Atlantic coast has, for instance, both a large transoceanic commerce and a large coasting trade, and several of its harbors rank among the world's great seaports. On the other hand, there are considerable stretches of the western and northern Alaska coast which are approached by very little shipping. The coasts of New England and of southern Alaska are rock bound and rugged and very intricate, with indentations, islands, rocks, and reefs; most of the Pacific coast is precipitous and rocky but of simple outline; and much of the South Atlantic and Gulf coast is low and sandy, of simple contour but with extensive inside navigable waters.

On the Atlantic coast north of Cape Hatteras, with slight exceptions, the main lights are placed at such intervals that their arcs of visibility overlap. The American shores of the Great Lakes are nearly continuously lighted, as are the South Atlantic coast from Cape Romain to the end of the Florida Reefs, and about half of the Pacific coast. On the balance of the Atlantic, Gulf, and Pacific coasts there are unlighted stretches between the lights which stand on the projecting headlands. Along the enormous coast line of Alaska there are only a few general coast lights, but the principal inside channel is nearly continuously lighted. On the great Mississippi River system there are 2,696 aids marking 4,246 miles of channel, being an average of about two aids to each 3 miles of channel.

The conditions as to fog differ greatly on various parts of the coasts of the United States. The North Atlantic coast and portions of the Pacific and Alaska coast are extremely foggy, while on the South Atlantic and Gulf coasts and in Porto Rico and the Hawaiian Islands there is little fog. The average number of hours of fog for a year decreases from 874 hours on the coast of Maine to 165 hours on the South Atlantic and Gulf coasts. There is a moderate amount of fog on the Great Lakes, the average of 116 stations being 332 hours a year. The highest record of fog for a year at any station is 2,734 hours (about 30 per cent of the total time) at Seguin light station, Maine, and there is a record of 2,145 hours of fog in a year at the San Francisco Light Vessel.

The distribution of fog signals along the coasts has, of course, conformed to the needs imposed by these fog conditions. On the Atlantic coast from Cape Lookout northward there are 610 fog signals of all kinds, including sounding buoys, while on more than double this extent of coast south of Cape Lookout and along the Gulf coast there are 103 fog signals. If sounding buoys are not included, there are along the Atlantic coast from Cape Lookout northward 330 fog signals, or considerably more than half of the total of 577 maintained by the Service; there are 32 on the South Atlantic and Gulf coasts, 76 on the Pacific coast, 10 on the Alaskan coast, and 129 on the Great Lakes. There are no fog signals in Porto Rico and the Hawaiian Islands. Of the total of 467 bell and whistle buoys maintained, 280 are on the northern half of the Atlantic coast, 34 on the Great Lakes, and 71 on the Pacific coast.

An accurate and thorough hydrographic survey of the coast is a necessary preliminary to the intelligent location of lighthouses and buoys and beacons; the relation of the headland, rock or shoal to the navigable water areas must be known and studied before the guide mark can be placed in the best position. It is true that lighthouses had been established on the prominent headlands before accurate charts existed, but it is evident that buoys and beacons and lights can not be systematically placed until waters have been charted; in fact, without an accurate chart it is always possible that a buoy or beacon may be stationed so as to lead a vessel directly onto some hidden and unknown danger.

The relation of these works of surveying a coast and of properly marking it is close and supplementary. The reef or dangerous rock, when it is located in the survey, requires the buoy or spindle to mark it if near the track of navigation. The survey not only develops the proper location for the aid to navigation, but the chart when published is the best means of giving information as to the lighthouses and buoys and their location with respect to the channels and navigable waters.

The wire-drag work in the development of shoals which has been extended so greatly in recent years by the Coast and Geodetic Survey and the Lake Survey has been of great value in definitely determining dangers and clear areas. This work is an excellent example of the related duties of the Coast and Geodetic Survey and the Lighthouse Service, for immediately on the discovery of uncharted dangers by the wire drag the data are furnished to the latter, and if the obstruction is of a character to imperil shipping it is promptly marked by a buoy or otherwise. An example of this was the wire-drag work last year in the approaches to Portland, Maine, which developed the necessity for three additional buoys, and the moving of two buoys to better mark the shoals. A number of additions to and changes in the buoyage in the vicinity of Key West, Florida, have been made as a result of the wire-drag surveys there, and there are many other instances of the same character. Wire-drag work in Alaska has resulted in the addition of buoys to mark sunken rocks in the channels there. One difficulty of extending the aids to navigation in Alaska has been the lack of sufficient surveys on considerable portions of that coast.

The lighthouse work and the coast survey work have an important object in common; the purpose of both is to protect mariners and keep them out of danger, to give the shipmaster all possible help to steer a safe course. One gives him the map showing where the water is safe for his vessel, the other gives him the light, foghorn, and buoy to guide him over this course. Although their primary duty is to keep vessels out of danger, yet frequently they have opportunity to aid in life-saving and rescue work. The Lighthouse Service has its employees at every prominent headland and harbor entrance and its men on lightships and tenders on every section of the coast. These keepers and sailors effect many rescues and save many boats each year, and do not hesitate to take personal risk when necessary.

The two Services cooperate in many ways. The Coast and Geodetic Survey has made special surveys needed in connection with selecting the location for lighthouses and has determined the positions of landmarks necessary for locating buoys. The accurate positions of lighthouses are obtained in the triangulation of the Survey, and the positions of buoys are checked when surveys are in progress. The Lighthouse Service promptly marks new dangers located in the course of surveys and changes the position of buoys and other aids as is shown to be necessary by revised hydrography. It aids the Survey with any information obtained by its vessels, or otherwise, that will be of use in correcting the charts.

The Lighthouse Service maintains nearly 12,000 aids to navigation aside from those on the interior rivers. The Coast Survey, the Lake Survey, and the Hydrographic Office publish about 800 different charts of the waters where these aids are located. The same section of the coast must necessarily be published on several different scale charts. With the overlaps of charts and the necessary repetition on different scales it is probable that a section of coast is on the average published three times. Sometimes a single aid may be shown on as many as six different charts, so that it may be estimated that the 12,000 aids are represented 20,000 times or more on the charts. During the last year 1,949 notices to mariners were published by the Department of Commerce, a large portion of which refer to changes in the positions or characteristics of aids to navigation, these changes being made necessary by changing conditions. It is evident, therefore, that a great amount of work is required in locating the aids correctly on the charts and in keeping this information correct, and in this work there must be close cooperation between the Lighthouse Service and the Coast and Geodetic Survey. On a single chart, that of New York Harbor, there are shown 299 aids to navigation.

The relation of the work of these two services was recognized in the organization of the Lighthouse Board, which for 58 years conducted the lighthouse work of this country. The law required that in the membership of this board the President should appoint "two civilians of high scientific attainments," and for nearly all of this period one of these civilians was the Superintendent of the Coast and Geodetic Survey, and the records of the board show active participation by these members, which included the names of Bache, Peirce, Mendenhall, and Pritchett.

As both nature and the works of man are constantly changing the coast line, channels, and harbors, and as the course and needs of commerce also are ever varying, it is evident that both the charts and the beacons for the aid of mariners must ever be corrected and modified; therefore the cooperation in these two important works must always be continued as in the past.

Mr. Jones: After hearing Commissioner Putnam's very excellent address, I think we can all realize how indispensable is the cooperation of the two bureaus.

Our last address this evening is on "Hydrography and Charts, with Special Reference to the Work of the United States Coast and Geodetic Survey."

Hydrographic surveying and the making of charts due to improved methods and new apparatus have changed greatly in the last half century. We have with us one who is fitted to tell us how these are done, and I take pleasure in introducing to you Mr. George Washington Littlehales, hydrographic engineer of the Hydrographic Office of the United States Navy.

HYDROGRAPHY AND CHARTS, WITH SPECIAL REFERENCE TO THE WORK OF THE UNITED STATES COAST AND GEODETIC SURVEY

Mr. LITTLEHALES: A century ago the States and the people, through their Senators and Representatives in Congress, authorized the President of the United States "to cause a survey to be taken of the coasts of the United States in which shall be designated the islands and shoals, with the roads or places of anchorage, within 20 leagues of any part of the shores of the United States; and also the respective courses and distances between the principal capes or headlands, together with such other matters as he may deem proper for completing an accurate chart of every part of the coasts within the extent aforesaid."

The Congress has shown the strength of intention underlying this enactment by making almost continuous annual appropriations throughout the 100 intervening years, and by authorizing as an additional aid to the prosecution of so important a public task large drafts from the Army in earlier years, and yet larger ones from the Navy whenever and as long as they could be spared from the exacting needs of the battle fleet.

How was this justifiable, and how justifiable was it? The results served the life of the Nation. No cargo is ever exported or brought home without invoking the protection of this Survey; no ship ever enters or leaves our ports without receiving its fostering aid.

In proceeding oceanward from the borders of the continent, along which the triangulation or mensurational framework of the Coast and Geodetic Survey has been conducted and the topography delineated, the land dips gradually under the sea. It is the province of marine hydrography, by means of measurements of the depth of sea located in position with reference to the triangulation on shore, to discover and to chart the features of these submerged bordering lands, thereby indicating the hidden dangers to be avoided by mariners and the channels where safety is to be sought in the guidance of shipping. Thus, the mission of the hydrographer is that of a pathfinder to lead the way to our ports and harbors, not only at home but also in the distant countries beyond the seas. This he does by means of charts[1] portraying the conditions in the near and remote approaches to the coasts, and in the bays and roadsteads, and in the ports and anchorages. Their numbers reach hundreds and hundreds, and they are all graded in their design and execution to suit the needs of those who need the sea—to tell the seafarer when there is a favoring tide, and by how much his compass declines from the true meridian, and to warn him where his safety is beset.

It must be with no small degree of pride that men should trace their professional lineage to a calling which has prepaid the premiums of a policy of insurance upon the sea-borne commerce of the United States and made the coast of the United States its best known geographical

[1] Reference was here made to the specimen charts and publications of the Coast and Geodetic Survey exhibition, which occupied the hall of approach to the chamber in which the exercises were beiug held.

feature—a calling reaching so far back into the history of our country, so enriched with the heroisms of the sea and with honored names, and so unexcelled for the aggregate of its influences in promoting the security of shipping and safeguarding the lives of seamen.

Mr. Jones: I want to thank Mr. Littlehales for his very excellent paper and to announce that our exercises will be continued to-morrow afternoon at 2 o'clock.

AFTERNOON SESSION, APRIL 6, 1916

Mr. JONES: Ladies and gentlemen, yesterday we heard a great deal of the history of the Coast and Geodetic Survey during the past century and its work on the waters of our vast country. To-day we will hear something about its work on land. There are very few things that interest scientists, as well as business men, more than measuring the size and shape of the earth. The geodesist is coming into his own, and each day we see added interest and we know more of the real value of his work throughout our country.

We have with us this afternoon a man who has already served his apprenticeship in the United States Coast and Geodetic Survey and through his work the division of geodesy in a large measure was placed on a firmer footing. The subject of his address will be "The Contribution of the United States Coast and Geodetic Survey to Geodesy." I take great pleasure in introducing to you Professor William Henry Burger, of the College of Engineering, Northwestern University, Evanston, Ill.

THE CONTRIBUTION OF THE UNITED STATES COAST AND GEODETIC SURVEY TO GEODESY

Professor BURGER: In the earlier days of the Coast Survey, whose centennial is now being commemorated, the geodetic function, as such, was little in evidence. It was then simply an aid in carrying on the work outlined in the act of 1807, which provided for a survey of the coasts of the United States, in order to provide accurate charts of every part of the coast and adjacent waters.

Upon the reorganization of the Survey in 1843 the corner stone was laid for that fine system of geodetic works which the Survey has at present. In this reorganization two very prominent features, from a geodetic standpoint, are to be noted. The first is the man who was the dominant figure in the board of reorganization and the second is the principles he advocated. Probably no other man has had the influence upon the geodetic operations of the Survey as had Superintendent F. R. Hassler, and probably no one thing has been of such importance to these operations as the scientific methods proposed by him. To him belongs the credit that to-day the operations of the Survey are bound together by a trigonometric survey with long lines and executed by the most accurate instruments and the most refined methods, rather than being correlated by purely astronomical observations. Due to his farsightedness, the best of foundations was thus laid for geodetic operations, and from this time geodesy became an important part of the Survey's work.

A further impetus was given to the work when, shortly after the close of the Civil War, Congress authorized a geodetic connection between the Atlantic and Pacific coasts of the United States. The result of this was the great transcontinental arc of triangulation along the thirty-ninth parallel of latitude, one of the most famous arcs in the history of geodesy and one which has helped to place the United States in the front rank of the nations carrying on geodetic operations. One of the immediate results was the recognition of the geodetic function as an important part of the Coast Survey's work, and in 1878 the Survey's title officially became "The Coast and Geodetic Survey."

TRANSCONTINENTAL ARC

The great triangulation system along the thirty-ninth parallel is probably the greatest single contribution to the world's geodesy that has been made by any one country. It marks an epoch in the scientific history of the United States and in that of the world. The results of the work are most important and far-reaching to geodesy, geography, geology, and the other earth sciences.

It is the longest arc of a parallel ever undertaken by a single nation, being more than 48° of longitude between its extremities, or about one-eighth of the earth's circuit, and is more than half the length of the combined arcs (measured by various nations) used by Clarke in deriving the figure of the earth in 1880.

The nature of the country traversed by the arc developed new ideas in reconnoissance, signal building, triangulation, and methods of computing, which have had an important bearing on all subsequent work. By means of it unity and consistency have been secured in the geodetic work of the Survey. It has proved a bond between the many separate parts of the Survey's work. These, at first, existed as a number of detached portions, in each of which the datum was necessarily dependent upon the astronomic observations. The transcontinental triangulation joined these detached portions and made them into one continuous system dependent upon the same geodetic and astronomic data.

From a higher scientific standpoint this arc is a great contribution to geodesy in giving data for the determination of the earth's shape and size, but, like any other arc of a parallel, it must be combined with an arc in the north and south direction to obtain its full power in this respect.

EASTERN OBLIQUE ARC

In the eastern oblique arc the United States has another arc of note, which covers some 22° and extends from the Bay of Fundy to the Gulf of Mexico at New Orleans. This was the direct result of Hassler's plans, was the scene of his last labors, and had for its main object the binding together of the detached surveys of the harbors on the Atlantic coast.

Unlike the transcontinental arc, it has all the elements necessary for the determination of the figure of the earth. It is the first arc which made use, on a large scale, of measurements oblique to the meridian. One of its great effects on the geodesy of the United States was that through it came the rejection, in 1880, of Bessel's spheroid of reference and the adoption of the Clarke spheroid of 1866 as the reference spheroid to be used by this country.

ASSISTANT CHARLES A. SCHOTT

Many men took part in furnishing the data for these two arcs and in the resulting computations, but no name stands forth so prominently as that of Assistant Charles A. Schott, the "Grand Old Man," who for more than 50 years was identified with the work of the Survey. His labors in the field and office did much to bring this work to a most successful finish, and it is fitting that credit be given him for the two monumental volumes of results which it was his privilege to see completed before death came. For this work, and for the work done in many other lines of the Survey's activities, I do not hesitate to mention the work of Mr. Schott as one of the great contributions made by the Coast and Geodetic Survey to the geodesy of the world.

The Survey was particularly fortunate in having such a man in charge of geodetic work, one who could see the full wisdom in the plans of Mr. Hassler, who consistently worked for their fulfillment, and who was able to have these plans transmitted to his successors, Assistant John F. Hayford and Assistant William Bowie. This furnished a continuity of plan which probably stands unrivaled in the scientific history of the world, and has been one of the big factors in the great success attendant upon the geodetic operations of the Survey.

RECENT TRIANGULATION

Since the completion of the two arcs mentioned, the Coast and Geodetic Survey has added many more arcs to its system, until the total length of the combined arcs is more than 150° of a great circle of the earth, or about three-sevenths of the circuit of the globe. Incorporated into the system and placed on one datum are also the many miles of coast triangulation of the Survey and much of the triangulation executed by the Lake Survey and by the United States Engineers, until now the system stands without an equal in any nation.

In the closing years of the last century a new era in geodetic operations by the Coast and Geodetic Survey was begun. The work of the past was searched for the best in instruments and methods, field and office methods were standardized, limits of accuracy were set, and where it seemed advisable new methods and instruments were devised to meet the changing conditions of the work. This era may be characterized as a period of great speed and low costs, with the previous accuracy maintained.

Never before had triangulation been executed with such rapidity and with such economy in operations. It is significant that this was attained without a reduction in accuracy and, in fact, had the effect of an ultimate increase in accuracy, for, owing to the speed, many more circuits could be added to the network, thus strengthening the whole system.

As an example of the speed and economy of operation in this last period the Texas-California arc of about 20° is cited. The reconnoissance on this arc was done by two men in 145 days and the primary observations in a total of 183 days at a cost of $400 per station and of $32 per mile of progress. Nearly 50 years were spent on the transcontinental arc of 48°, with a cost of $2,000 per station and $200 per mile of progress. This comparison is not intended to be derogatory to the latter arc, for the work on that arc was the best of any up to that date, and it was only through its work that the economy and speed of the later work was made possible. It is believed that no extensive arc in any other country equals the Texas-California arc or some of the other recent arcs of the United States in these respects.

Since about 1900 practically all of the reconnoissance and signal building has been in the hands of one man, Signalman Jasper S. Bilby, who as an expert along these lines probably stands unrivaled in the world to-day.

UNITED STATES STANDARD DATUM

A direct and far-reaching geodetic movement of influence, not only to the United States, but also one of great importance to the North American Continent, and also to the whole world, was initiated in the adoption by the Survey (in 1901) of the United States standard datum. It placed the geodetic work of the Survey on one datum for the correct coordination of the geographic latitudes, longitudes, distances, and azimuths. From the scientist's standpoint it furnished accurate correlation of data for a study of the figure of the earth, of isostasy, and for other related sciences.

By its adoption as the standard datum for geodetic operations in Canada and Mexico, it became a matter of international importance, and consequently its designation was changed by the Survey in 1913 to that of the "North American datum." Plans are now under way for carrying the primary triangulation of the United States and Canada to the Yukon, and the prediction is here made that eventually the 50 miles which separate Alaska from Siberia will be spanned and a junction be effected with the great systems of Asia, Europe, and Africa. Then, with the extension from Mexico through Central and South America, the data will be available for a "world datum," and the final word will have been said in the geodetic work of the earth.

BASE-LINE MEASUREMENTS

Closely related to, and forming an integral part of the triangulation executed by the Coast and Geodetic Survey, is the measurement of the base lines for controlling the lengths in triangulation. In this work the Survey has furnished much of interest and of value to the geodesist. Ever has it kept keenly before it the necessity for refined measurements, and many valuable devices to accomplish this desired result have been added by members of the force.

BASE BARS

The Duplex bars, invented by Assistant William Eimbeck and constructed by E. G. Fischer, are probably the best form of base bars ever devised, and gave a very high degree of precision; but they were soon replaced by the tape as a form of base apparatus.

The only bar used in the United States, and probably in the world, which gives entire satisfaction, so far as accuracy is concerned, is the iced bar, designed by President R. S. Woodward, of the Carnegie Institution, when an assistant in the Survey. Owing to the great cost per kilometer of base of using this form of apparatus for field work, when compared with the cost of using tapes, the iced bar is now used only for standardizing other apparatus, and for this purpose it remains unexcelled.

STEEL TAPES

In the Coast and Geodetic Survey the tape has supplanted the other forms of base apparatus. Credit for the introduction of steel wires and tapes for this purpose must be given to Professor Jäderin, of Sweden, but it was the accurate and extensive investigations made by Assistant Woodward in 1891 which caused the adoption of tapes by the Survey. He proved that steel tapes, when used at night, and standarized under the same conditions that prevail during the base measures, gave essentially the same high degree of accuracy as the bars, with about one-third of the cost and with far greater rapidity. It is practically certain that no more base lines will be measured by base bars, at least in the United States, except when it is necessary to standardize the tapes.

The remarkable measurement of nine base lines in one season, in 1900, by a single party, constitutes a noteworthy achievement. The nine bases had a total length of 43 miles and furnished a control of over 1,000 miles of triangulation. In order to eliminate constant errors, five different sets of apparatus were used, and an average accuracy corresponding to a probable error of 1 part in 1,200,000 was secured. With this work a new epoch in base-line measurement was introduced, for it proved, through the most rigid of tests, that the tape had no superior for speed, economy, and ease of manipulation.

INVAR TAPES

In the use of invar tapes base measuring took another long step forward. Many severe tests have fully proved their excellence. They are found to possess practically all of the good features of the steel tapes but have the added advantage that they enable bases to be measured in the daytime and even on sunny days, a fact due to the small coefficient of expansion of invar, which is only about one-thirtieth that of the steel.

Recently the plan has been adopted of having the bases measured by the triangulation party. By it base measurement has become simply an incident to the triangulation, and the cost has been reduced to about $60 per kilometer, a sum which is in great contrast to about $300 per kilometer with the Duplex bars.

PRECISE LEVELING

Practically all of the great nations of the earth have been actively engaged upon the difficult problem of determining the correct elevation of points far from their coast. It is a work which demands the highest degree of accurate observing and painstaking endeavor. It calls for especially designed instruments and methods of observation. These accurate elevations are needed for the reduction of base lines to mean sea level, for engineering operations of wide extent, and for the solution of scientific problems concerning gravity, the tides, and other work.

In this leveling of precision the Coast and Geodetic Survey has added much to the world's work by attainments in field operations, methods of reduction, and scientific study of errors involved. In its great precise level net (greater than that of any other nation) there are more than 13,000 bench marks, of which the elevations have all been accurately fixed through a single least square adjustment of more than 80 circuits with a total length of more than 33,000 miles.

COAST AND GEODETIC SURVEY LEVEL

Among the instruments of precision employed by the nations for precise level work it may be truly said that none holds a higher rank than the type which has been in use in the Coast and Geodetic Survey since 1900. This level was designed and built within the Survey by E. G. Fischer, chief of the instrument division, and after more than 15 years of constant service in all parts of the United States has shown itself to be, indeed, a superior instrument for accurate and rapid leveling.

Before the introduction of this level the average rate of progress was less than 60 miles a month. Recent work, which is of much higher grade of accuracy, shows an average of about 100 miles, and one observer with a party of six men recently completed 148 miles of progress, or more than 300 miles of single line in one month. This constitutes a world record.

Although precise leveling has been brought to the highest perfection in France, the work of the Coast and Geodetic Survey, by the very magnitude of the operations, by the instruments employed, and by the economy in speed and cost is certainly without an equal in the geodetic world.

ASTRONOMIC INSTRUMENTS AND DETERMINATIONS

Considering astronomy as a definite part of its geodetic functions, the Survey by its inventions and improvements may justly claim to have demonstrated the superiority of the American methods for the determinations of terrestrial latitudes and longitudes and has secured their adoption in the practice of every great nation in the world by the incontestible superiority proved for them.

The credit for the discovery of the differential method for the determination of latitude with the zenith telescope, despite a reference to the principle by the Danish astronomer Horrebow in the early part of the eighteenth century, is due to Captain Andrew Talcott, United States Corps of Engineers, who first employed it in 1834 and 1835, in the survey of the boundary line between Ohio and Michigan. But the introduction of this admirable method to its present world-wide use is due in a great measure to the wise appreciation of Superintendent Bache, who almost with his induction into office recognized its great importance and initiated the developments which inspired the following tribute from the famous astronomer Gould: "To Bache we owe the recognition and adoption of this transcendent method and to him also those refinements of process and improvements of apparatus by which alone its accuracy is rendered possible."

The distinction due for the discovery and introduction of the method now exclusively used for the determinations of longitudes is even more singularly an honor appropriate to the Survey, which, within a few months after the successful opening of Morse's first telegraph line, began the experiments for an application of its use to longitude determinations with such success that no change in principle has been found necessary in the methods perfected by Bache and his assistants. Thus, the present universally employed methods for exact determinations of the earth's most important geographic coordinates have been suggested and perfected by American genius. To the work executed by the other civilized nations of the world the Survey has contributed many hundreds of astronomic latitudes, longitudes, and azimuth determinations, principally at stations connected with the great triangulation system. Methods of observing and computing have been standardized with a decided improvement in speed and economy and with a most satisfactory increase in the annual amount of work executed.

Since about 1904 all of the primary azimuths, in so far as was practicable, have been observed by the triangulation party during the progress of the work. It is believed that this plan gives the highest degree of accuracy, for the measurements are made under exactly the same conditions as the triangulation with which they are concerned, and the cost is very materially reduced.

TELEGRAPHIC LONGITUDES

The formation of the great telegraphic longitude net of the Coast and Geodetic Survey is a geodetic feat worthy of special note. No less than five trans-Atlantic determinations have been made which serve to connect the longitudes of the United States with Greenwich and Paris, and more than 200 stations are included in the net which covers this country. Finally, through a trans-Pacific determination made by the Survey, supplemented by a similar one made by Canada, the last link in the telegraphic longitude circuit of the globe was completed, and thus nearly all of the longitude observations made in the world are united into one great single system, accurately correlated through this circuit.

TRANSIT MICROMETER

Among improvements made by the Survey to the instrumental equipment used in field astronomic work another of recent introduction deserves mention. This is the transit micrometer used in determination of time by stars at meridian passage. Although the transit micrometer had been in use at fixed observatories, it was not until the investigations made at the Coast and Geodetic Survey in 1904 that its adaptability to portable transits was thoroughly proved. The many tests it has had in actual field work have shown for it many features of excellence. With its use the relative personal equation between two observers is so small as to be masked by the accidental errors of observation and is certainly not more than one-tenth as large as the average, using the key. No interchange of observers is necessary, and the time of the determination of a difference of longitude is about one-half the time taken by the older method.

FIGURE OF THE EARTH

The very important problem of determining the shape and size of the earth is probably the climax, from the scientific point of view, in the geodetic work of the Survey.

Reference has already been made to the use of the arcs of triangulation in determining the figure of the earth. When many arcs, both meridional and latitudinal, are all joined together on the same trigonometric and astronomic basis, the area method, developed in the Coast and Geodetic Survey since about 1901, is without doubt far superior to the arc method. In it are all of the features of the arc method, to which many important new features are added. Using the great system of triangulation in the United States to furnish the area factor and the many astronomical measures connected with the system to furnish the curvature factors, a value for the figure of the earth was derived which is of a very high degree of accuracy. The investigations and results obtained in this work are noteworthy contributions to geodesy. Some of the prominent features of this investigation are shown in the wide area treated, the large number of astronomic observations involved, and the unusual methods of computation used. Topographic irregularities within 4,000 kilometers of each astronomic station were considered, and account was taken of possible distribution of density beneath the surface of the earth. These features, together with the actual results obtained, make this a monumental work.

By a study of the station errors, or deflections in the verticals, which were developed when the astronomical and geodetic determinations were compared, evidence was brought forth which established the fact that the condition of isostasy exists in the earth, a fact which is of interest and value to geodesy and geology.

These studies of the figure of the earth and isostasy have attracted the attention of the scientific world. Doctor Woodward, the distinguished geodesist, is authority for the statement that the work done by the Coast and Geodetic Survey on isostasy is the greatest contribution to geodesy since the time of Gauss and Bessel.

GRAVITY MEASURES

Another method of attacking this important problem of the earth's shape and size is by the use of the pendulum in the determination of gravity. The contributions of the Coast and Geodetic Survey to this field of geodesy are given in the results of more than 30 foreign stations and of 219 stations in the United States.

Happily the gravity conference held in 1882 indorsed the plan of using the invariable pendulum and of employing the differential method of carrying on gravity work, and the Survey's present excellent equipment and methods are the direct results. In its present type of apparatus, known as the Mendenhall pendulums, the Survey has a form which for compactness, portability, precision, and ease of operation ranks well among the best in this field of endeavor.

Two features in recent gravity work are worthy of note. One is the application of the interferometer to the measurement of the flexure of the pendulum support, thus giving a direct measurement of this small quantity in terms of a wave length of light. It is believed that the resulting corrections to the period of the pendulum are more accurate than those by the older static method where the corrections were derived under exaggerated conditions. The interferometer has been in use for about eight years as a field instrument, and determinations of the flexure have been made at about 140 gravity stations, through a very wide range of conditions in piers and external vibrations.

The second feature worthy of note in recent gravity work is the deriving of the rate of the chronometers from time signals at noon, sent from the Naval Observatory over the lines of the Western Union and Postal Telegraph companies, a distinct advantage over the older method. By it the local time observations are dispensed with, the time of occupation of a station is decreased, and the labor of preparing the station greatly lessened, all of which contribute to a lowering of the cost per station occupied. In connection with this it is interesting to note that Assistant Schott in 1882 made the statement that "time furnished telegraphically by an observatory whose clock is protected from changes of temperature and pressure will be preferable to any local determination at a field station."

FIELD AND OFFICE FORCE

Little has been said of the men who have composed and do now compose the field and office force of the Coast and Geodetic Survey. What the Survey is and accomplishes is due to these men, and to the spirit which influences them. To them must be given the credit for much that the Survey has contributed to geodesy. It would be difficult to find a body of men of greater enthusiasm for, or a higher scientific attitude toward, their work. They have a careful devotion to duty and an interest in the success of the Survey and its work, a fact which has developed a corps of workers of unrivaled excellence.

They have ever been most alert to adapt new discoveries, made in the various fields of science, to the needs of the Survey, and to plan new and improved instruments; while to the theoretical work of geodesy they have added much by critical discussion and extensive study of results.

Workers must have tools, and this fine body of skilled observers would be seriously handicapped in their work if suitable equipment were not furnished them. The Survey is particularly fortunate in having a body of skilled artisans in the instrument division, under the supervision of a most highly efficient officer. In the division there have been designed or built nearly all of the instruments of precision which have helped so materially to place the Coast and Geodetic Survey in its present high position.

Of the relation of the geodetic work of the Survey to that of the world, as shown by its share in the operations of the International Geodetic Conference, only slight reference is here made, for this subject is dealt with in an address by former Superintendent O. H. Tittmann, who is much more capable of presenting this subject.

In the foregoing the endeavor has been made to give some idea of the contributions which the Coast and Geodetic Survey has made to geodesy. Of necessity much has been omitted, but what has been given will bear witness that the world's geodesy has been greatly enriched by the work of the Survey.

A test of the greatness of the geodetic work of the Survey may be had in a review of the comments made by prominent men in other organizations and countries, by men who are well qualified to judge. They all accord to the geodetic work of the Survey a very high place in the geodesy of the world. One comment only will be here given as a fitting close to this brief review of the contributions made by the Coast and Geodetic Survey to geodesy.

Commandant Perrier, the French geodesist, in speaking of the work of the Survey says:

> There is no example in the history of geodesy of a comparable collection of measurements, made with so much determination, such rapidity, and such powerful means of action, and guided by such an exact comprehension of the end to be attained.

Mr. Jones: I am sure we are grateful to Professor Burger for the clear manner in which he has told us of the development and the value of geodesy.

Our next address will be "The Civil War Record of the United States Coast and Geodetic Survey, and What the Survey is Doing Toward Preparedness." When the Civil War began, over 50 years ago, the field officers of the Coast Survey offered their services, and I think the record they made speaks for itself. We are honored this afternoon in having with us one who has served with the Coast and Geodetic Survey, having been detailed from the Navy Department, and one who has a long and honorable career with that department. I take pleasure in introducing to you Admiral Richard Wainwright.

THE CIVIL WAR RECORD OF THE UNITED STATES COAST AND GEODETIC SURVEY, AND WHAT THE SURVEY IS DOING TOWARD PREPAREDNESS

Rear Admiral Wainwright: My acquaintance with the United States Coast and Geodetic Survey for over 60 years is my warrant for attempting to give the record of the field force of the Survey during the Civil War.

My earliest memories of boyhood are connected with the Coast Survey office, when Professor Bache was Superintendent; and I knew the old office building thoroughly, from the weights and measures in the basement to the computers' rooms in the attic. I have many times during the war watched our troops on the farther bank of the Potomac, through a telescope, from the back windows of the old building. I have lived in primary triangulation camps and called out the heliotropers when time to use the bull theodolite, watched the assistants swing the needles, and followed the plane table. During this time I have listened to many talks about the deeds of the field force of the Survey and have met many of the assistants who served in the Army or the Navy during the Civil War. Their names would sound familiarly to the old cave dwellers of this city.

The Superintendent, being a graduate of West Point, was frequently consulted by the President and his war Secretaries. He was prominent in the work of the Sanitary Commission and assisted the authorities in the prosecution of the war, to the best of his powers, both with advice and with personal effort. Members of the field force were early volunteers of their services to the country, and their assistance was eagerly sought by generals in the field and admirals afloat.

At the outbreak of the war both the Army and the Navy were furnished with a vast amount of information from the Coast Survey. The material in the office was rapidly put in the shape of hydrographic notes, the unpublished maps and charts were printed and with the memoirs of the coast were placed in the hands of the departments. The officers of the Survey were in frequent consultation with officers of the Army and the Navy in regard to operations along the coast; and in nearly all naval and military movements they aided by making reconnoissances and soundings, placing buoys, and piloting in interior waters. Detailed surveys were requested and made in the regions traversed by the Army of the Potomac and at other points that were included in the operations of the war.

The following extracts are from an article by Richard Meade Bache and serve to give some idea of the duty performed by the field force of the Coast Survey. As there were assistants attached to headquarters in nearly every active operation, it is only possible to give a few of the most important notices. Several served throughout the war with the same commanders, many rose to high places in their confidence, and all were at different times commended for their gallant services.

After the attack on Port Royal, Commodore du Pont reported: "By the skill of Commodore Davis, the fleet captain, and Mr. Boutelle, the able assistant of the Coast Survey in charge of the steamer *Vixen*, the channel was immediately sounded out and buoyed." And General Sherman reports: "It is my duty to report the valuable services of Mr. Boutelle, assistant in the Coast Survey, in assisting me with his accurate and extensive knowledge of this country."

In the year 1862, 32 Coast Survey officers rendered service in military operations. Subassistant Dorr narrowly escaped being killed before Yorktown. His instrument was shivered and a picket near by was killed. Messrs. Bradford and Boyd while surveying on James Island, South Carolina, made prisoners of an attacking party of the enemy. Subassistant Oltmanns was dangerously wounded while on a reconnoissance up Pearl River. During this year Major Palmer died of a disease contracted during the peninsular campaign.

After the bombardment of Forts Philip and Jackson, below New Orleans, Admiral Porter reported: "The results of our mortar practice here have exceeded anything I ever dreamed of; and for my success I am mainly indebted to the accuracy of the positions marked down under Mr. Gerdes' direction by Mr. Harris and Mr. Oltmanns. They made a minute and complete survey from the 'jump' to the forts, most of the time exposed to fire from shot and shell and from sharpshooters from the bushes."

In 1863 Admiral du Pont wrote to Assistant Boutelle, commanding the *Bibb:* "Your examination of the channels and water on the Charleston bar seems to have been conducted with great skill and boldness, and I beg you to receive my thanks and commendation for the same and for the important information obtained."

At this time Mr. Robert Platt, the executive officer of the *Bibb* was detailed to pilot the *Weehawken* and was temporarily disabled when a bolt broke under the concussion of a heavy shot from one of the Confederate batteries.

After the first attack on Fort Fisher, Admiral Porter reports: "I inclose herewith the report of Commander Rhind, with the names of the gallant fellows who volunteered for this desperate service. Allow me to mention the name of Mr. Bradford, of the Coast Survey, who went in and sounded the place where the *Louisiana* was to go in, and has always patiently performed every duty he has been called on to carry out."

These few extracts, from many reports, serve to show that the field force of the Coast Survey gave valuable military service to their country during the Civil War. Afterwards they returned to their regular duties without any of the rewards of rank or pay or pension for themselves or their families, so freely distributed at this time for military services; but they had the satisfaction that is the reward of all earnest workers of knowing that—

Duty done
Is honor won.

Many of the naval officers who served on the Coast Survey prior to the Civil War distinguished themselves in that conflict. Some time after the war naval officers were again detailed to duty with the Survey. At this time the fortunes of the Navy were at a low ebb; our ships old and useful only for peace purposes. As a war instrument the Navy was a farce. The block in promotion kept officers in the lower grades for the best portion of their lives, and they only assumed the responsibilities of command when on the eve of retirement. Work on the Coast Survey had much to do with keeping alive the spirit of the officers of the Navy at this time. They had the opportunity of learning to command and to exercise their own initiative. They had to learn to conquer difficulties and to make things do, for in no other Government service is more work required and smaller means provided for its accomplishment than in the Coast and Geodetic Survey. I am glad to see that the present Superintendent is gradually forcing the Coast and Geodetic Survey from its dignified scientific obscurity into the light of the public eye. The large scientific associations have always supported the Survey, but they can only act effectively when some important subject is placed before them. When money is needed for the many daily requirements of the work Congress will not appropriate liberally unless the public is interested.

The constant work of keeping our numerous harbors and channels correctly charted, the aids to navigation located, and the tides computed is necessary for the commerce of peace as well as in preparation for war. The increased draft of ships now in use has necessitated the employment of the drag to discover hidden rocks and to insure the safety of both merchant vessels and battleships; and there are points where a close survey is of value to the Navy, although of little use to commerce.

In time of war the field force of the Coast Survey will be needed, as it was during the Civil War. The Army and Navy are both very short of officers. A trained topographer would always be of value on the staff of a general and the Chief of Staff or the engineer would find much useful employment for him. In modern war, with long-range guns, the general must visualize his work by close reference to the map, and a topographer from the Coast Survey would find little training necessary to keep the new features and movements of the troops plotted ready for the commanding general. With his draftsmen he could work in new details, enlarge maps when necessary, and in general take charge of the staff maps. He could aid the engineer in running trench lines, laying lines for defense, and plotting his own and the enemy's batteries. In fact, perform all the topographical duties and some of the military duties of an Army Engineer.

The Navy is not so apt to need advance surveys and piloting now as during the Civil War, because of finished surveys and completed charts, but there is no question but that a skilled hydrographer would prove a most valuable addition to the staff of an admiral. His power of quickly locating his position on a chart would be of assistance in bombardments, blockading, mining, and countermining. In fleet actions the admiral must have an aid to keep his fleet and that of the enemy plotted on a proper scale chart. Especially at extreme ranges, changes in bearing and distance and even in formation can be more readily detected in this way than by the eye, and important time may be gained by this means when trying to outmaneuver the enemy. A hydrographer accustomed to work on a boat sheet would soon become a rapid worker on such a plotting sheet. He would only find that the methods necessarily used were less accurate than those to which he has been accustomed.

There is no doubt but that the General Staff of the Army or the Bureau of Operations of the Navy could find many other useful duties in time of war for the members of the field force of the Survey. To-day preparedness is in the mouth of every man. Its adoption by the President has made it a national issue, and in the eyes of military men it has long been a national necessity. Would it not work for efficiency and preparedness if at the present time the positions and duties were determined and the men to fill them selected? Much lost motion will be prevented and better cooperation insured if some arrangement is made by the three services.

There have been many skilled scientific men attached to the United States Coast and Geodetic Survey. Some well known to their countrymen and others only known to the few interested in their specialty. On the practical side the work has been well done and with economy. The Survey charts stand at the head of all others for accuracy, execution, and general usefulness. The field force of the Survey has always given loyal service to the country. If war should come, they and their distinguished Superintendent will be prompt to offer their services. They will again be found ready. May they then find the Nation more grateful than did those who were detailed from the Survey during the Civil War.

Mr. Jones: I know we are very thankful to Admiral Wainwright for telling us so clearly of the deeds of valor of those who were associated so many years ago with the Coast Survey. He can rest assured that if this country should be involved in another war the men of the Survey will again be found ready to do their part for their country.

Our next address will be on "The International Work of the United States Coast and Geodetic Survey." The Survey has not neglected the international work of the United States while attempting to do its purely national work. In fact, our work in its entirety might be considered as international.

We are very fortunate in having with us to-day a former Superintendent who has been interested in international work for many years. It gives me pleasure to introduce to you Doctor Otto Hilgard Tittmann.

THE INTERNATIONAL WORK OF THE UNITED STATES COAST AND GEODETIC SURVEY

Doctor Tittmann: It may justly give satisfaction to the members of the Survey that the results of its work are nearly all international in their scope.

The hydrographic and tidal surveys are obviously for the benefit of all mankind, because they safeguard the commercial intercourse of nations. Its geodetic work contributes to the knowledge of the earth's dimensions and constitution. The world's knowledge of terrestrial magnetism would be incomplete without the record of the observation of magnetic phenomena as they occur in the vast territory inhabited by us, and so with data relating to the tides. Thus, in the prosecution of its tasks, the Survey adds to our knowledge of the planet which we inhabit and thereby furthers the ultimate aim of all civilization, the intellectual development of mankind.

The theme assigned to me, however, is the international work of the Survey in a more restricted sense and refers to its labors in direct cooperation with other countries. With this interpretation the international boundary surveys are its most striking accomplishment.

BOUNDARY OF ALASKA

When Russia as a manifestation of her good will transferred to us Russian America for a purely nominal sum, the Coast Survey put its expert cartographers at work to compile an official map of the territory in question for the use of the Department of State. It bears the date 1867 and is entitled "Northwestern America, showing the Territory ceded by Russia to the United States," but it bears the name Alaska. This name was suggested by Charles Sumner in his great speech delivered on April 19, 1867, on the significance of the purchase.

In a personal letter to Mr. Hilgard, under whose direction the map was compiled, Mr. Sumner wrote: "I like the looks of the map. The addition of soundings is important." He made no comment in the letter on the representation of the boundary. The reason for this is probably to be found in the opening sentence of his speech. "In endeavoring to fix its character [i. e., of the cession] I am glad to begin with what is clear and beyond question. I refer to the boundaries fixed by the treaty. Commencing at the parallel 54° 40′ north latitude so famous in our history, the line ascends Portland Channel to the mountains, which it follows on their summits to the point of intersection with the 141° west longitude, which line it ascends to the frozen ocean, or, if you please, to the North Pole."

It may be remarked parenthetically that an intrepid American explorer, Peary, did visit the North Pole end of the line while he was formally attached to the Survey for the purpose of observing Arctic tides and that before he entered the Navy he had also served in the Coast and Geodetic Survey.

The following is one more quotation from Sumner's speech referring to the Survey: "An object of immediate practical interest will be the survey of the extended and indented coast by our own officers, bringing it all within the domain of science and assuring to navigation much-needed assistance, while the Republic is honored by a continuation of national charts, where execution vies with science and the art of engraving is the beautiful handmaid."

The references to the early connection of the Survey with Alaska show that in the delimitation of the international boundary it was natural that the United States should be represented by the Coast and Geodetic Survey all the more because its trigonometric and topographic surveys of the shores of southeast Alaska were essential for the coordination of the work farther inland. The local disputes which arose over the boundary, which according to Senator Sumner was "clear and beyond question," reached the first stage of settlement by a convention between the United States and Great Britain, which was signed July 22, 1892, and by a supplementary one of February, 1894, which provided for the mapping of the territory contiguous to the boundary.

The then Superintendent of the Coast and Geodetic Survey, Doctor T. C. Mendenhall, was appointed commissioner to represent the United States in a joint survey and Doctor W. F. King to represent the British Government. Doctor Mendenhall was later succeeded by Superintendent W. W. Duffield. Owing to the large area to be mapped and the brief time allotted to the work by the convention the commissioners decided on a joint survey with separate surveying parties, the parties of one country being accompanied by surveyor attachés of the other. To the officers of the Coast and Geodetic Survey was assigned the survey of the water courses and certain astronomical determinations; to the Canadian parties, the mapping of the intervening topography. For this they were especially fitted by their knowledge of and experience with photo-topographic methods without which the mapping could not have been accomplished in the brief time allotted to the work comprised between November, 1892, and December 31, 1895. The results of these surveys and of some supplementary ones made a little later to supply needed information were embodied in a series of 24 contoured topographical maps by the British commission and a series of 12 maps by the United States commission, both series being on a scale of 1:160,000. These maps were submitted to the Alaska boundary tribunal which convened at London in conformity with the treaty of January 24, 1903. Prior to the meeting of the tribunal, however, the discovery of gold and the rush of adventurers to the Klondike region had given rise to contentions in the region at the head of Lynn Canal, disputes which threatened serious complications.

To prevent these, a "modus vivendi" was agreed upon by the two Governments concerned, and Mr. Tittmann, of the Coast and Geodetic Survey, and Doctor King, of Canada, were appointed commissioners to mark a provisional boundary along the Tlehini River and across the Chilkoot and White Passes. They promptly performed the duties assigned to them in the summer of 1900 and necessary temporary monuments were placed at important points along the line agreed upon.

The services of the Survey were further invoked by the Department of State in the preparation of maps and for consultation with the counsel on the staff of General Foster, the United States agent before the tribunal. Two officers of the Survey accompanied him to London to serve as experts during the proceedings.

After the decision of the tribunal was rendered the two Governments promptly appointed commissioners to carry out the findings. The Superintendent of the Coast and Geodetic Survey, Mr. Tittmann, and the chief astronomer of Canada, Doctor King, were the men chosen to carry out the arduous task of delimiting the boundary of southeast Alaska, the region extending from the southern end of Prince of Wales Island to the one hundred and forty-first meridian, to which the decision of the tribunal of London appertained.

In the spring of 1904 the two commissioners personally erected the first monument on the boundary at the head of Portland Canal.

In 1906 another treaty relating to the demarcation of the one hundred and forty-first meridian resulted in the naming of the same commissioners to carry out its provisions. Time forbids an account of the field operations, which resulted in the successful delimitation and mapping of a boundary about 1,800 miles long. The field operations were brought to a successful conclusion in 1913 by the bold and energetic American and Canadian engineers, under the direction of the two commissioners first appointed.

NORTHERN BOUNDARY

As far back as 1857 officers of the Coast Survey were directed to assist an international commission in mapping the treaty boundary through the Gulf of Georgia toward the Strait of Juan de Fuca. From time to time the Survey was called upon to represent the Government in the re-marking of short sections of the boundary where the monuments had disappeared, or where it never had been marked. Thus, in 1892, Doctor Mendenhall, the Superintendent of the Coast and Geodetic Survey, was appointed commissioner on the part of the United States to mark the boundary in Passamaquoddy Bay, together with Doctor King, the British commissioner, but no joint report was made by the commissioners, owing to a disagreement in regard to the line through Lubec Narrows. A part of the line marked by them was adopted by the treaty of 1908.

In August, 1902, Superintendent Tittmann was designated as representative of the United States to re-mark the boundary between Lake Superior and the Pacific Ocean, and after further negotiations the Director of the Geological Survey and the Superintendent of the Coast and Geodetic Survey were, in June, 1903, designated as United States commissioners to remonument, in cooperation with the British commissioner, Doctor King, the boundary between the Rocky Mountains and the Gulf of Georgia. In 1905 the Superintendent of the Coast and Geodetic Survey was directed to cooperate with the British commissioner in making a temporary relocation of a small section of the boundary near Portal, North Dakota.

While the re-marking of the boundary was progressing during the years following 1903, it was done under informal agreements between the two countries. The great work was, however, put on a more formal and definite basis by the treaty of 1908, under which the Superintendent of the Coast and Geodetic Survey was appointed sole commissioner on the part of the United States for the demarcation of the whole line from Grand Manan Channel to the Pacific Ocean, with the exception of the water boundary through the St. Lawrence and the Great Lakes.

The Superintendent was succeeded as commissioner in 1915 by E. C. Barnard, for many years associated with the boundary survey as one of the principal engineers.

In the brief time allotted, this chronological statement is necessarily lacking in that interest which attaches to the history of our boundaries. For instance, there is an episode bearing on our boundary disputes which in our legal records bears the tantalizing title of "An open boat and cargo and three puncheons of rum," and I should like to satisfy your curiosity in regard to it. In regard to our northern boundary as well as the Alaskan one it should be pointed out that the trigonometric and topographic surveys coincidently made with the monumenting are as important and valuable as the delimitation itself.

UNITED STATES AND MEXICAN BOUNDARY

Between the years 1891 and 1895 this Government and that of Mexico remonumented their common boundary line. The Coast and Geodetic Survey was represented by A. T. Mosman, who was one of the three commissioners appointed to perform the work, and the Survey cooperated further by making determinations of geographical positions for the international commission.

NORTH AMERICAN DATUM

In connection with the activities of the Survey on these two boundaries it should be mentioned that the geodetic surveys of Canada, Mexico, and the United States have informally agreed to compute their geographical positions on the same reference spheroid, and to use the Coast and Geodetic Survey datum. In consequence the designation of the reference datum has been changed to the "North American datum." This important international agreement will tend greatly to simplify the geodetic computations in North America. Those in Europe are unfortunately not on a common datum.

THE SURVEY AND THE INTERNATIONAL GEODETIC ASSOCIATION

The International Geodetic Association is the outgrowth of a beginning made in 1862 by Prussia to unite the trigonometric surveys of the German States in a cooperative union for furthering the measurements of the earth. The father of the plan was General Baeyer, a coadjutor of the immortal Bessel.

It was first called the Mittel Europäische Gradmessung, and later on, when other European countries signified their willingness to cooperate, its name was changed to Europäische Gradmessung. Still later on, it assumed the name of International Geodetic Association, when transmaritime countries joined it. Among others the United States became a signatory power to the convention by the assent of Congress, which authorized the President to send delegates from the Coast and Geodetic

Survey to the meetings. While the United States did not become a party to the convention until 1889, the Coast and Geodetic Survey sent one of its officers as a delegate to the conference as early as 1878.

It is not possible to describe its labors, but it may be said that its vivifying influence on the progress of geodesy has amply justified its existence. At the last meeting our Western Continent was represented by Argentina, Chile, Mexico, and the United States. When the association established a chain of small observatories around the globe very nearly on the parallel of Washington, the Superintendent of the Survey, as a member of the association, was given charge of two of them, one at Gaithersburg, near Washington, and one at Ukiah, California. The object was to obtain a continuous series of observations on the variation of latitude. Such observations were made without interruption at both stations for over 17 years by American observers.

Seven years ago, at the request of the Superintendent, a sum of money was allotted to him by the association for the purpose of constructing a photographic instrument designed by Doctor Ross, the astronomer in charge of the Gaithersburg station. Doctor Ross with rare zeal and indefatigable industry carried on for three years a series of observations with this instrument coïncidently and in addition to the regular visual observations, and the results are unrivaled in accuracy and of great interest.

The gravity determination, made by Mr. Putnam, of the Coast and Geodetic Survey, between Washington, Greenwich, and Potsdam were made possible by the association. These important observations are the connecting link between the pendulum observations made in the Eastern and those in the Western Hemisphere.

Some years ago the plausible suggestion appeared in print that there might be a progressive displacement between the European and American Continents. This led to an agreement between the Prussian Geodetic Institute and the Coast and Geodetic Survey to make a trans-Atlantic cable determination between Potsdam and Washington with all possible refinement. The undertaking was in progress at the outbreak of the European war, but the cutting of the cable put a stop to the operations. It was possible, however, to compute a difference of longitude from the interrupted observations which verified the correctness of the old Coast and Geodetic Survey determinations and threw much doubt on the peripatetic habits of the continents.

THE SURVEY AND THE INTERNATIONAL BUREAU OF WEIGHTS AND MEASURES

Acting on a suggestion from the European Geodetic Association, the French Government invited this country to join other nations in the creation of an international bureau of weights and measures.

In 1872 two delegates were appointed to represent the United States, J. E. Hilgard, of the Coast Survey, and Professor Joseph Henry, of the

Smithsonian Institution. The latter, however, did not go abroad, this country being represented by Mr. Hilgard during the conference and scientific discussions which led to the successful establishment of the bureau and the construction of international standards of weight and length.[1] Copies of the standards were distributed to all signatory powers. Those intended for the United States were brought from France by officers of the Coast and Geodetic Survey.

MISCELLANEOUS

In 1900 the Survey undertook to cooperate in international magnetic work to be done in connection with Antarctic expeditions sent out by Germany and Great Britain. Since that time the Survey has frequently responded to calls for simultaneous magnetic observations and at all times is cooperating with the magnetic surveys of other nations.

As this address is chiefly a recital of work done jointly with other nations and under formal agreements, much interesting scientific work of international scope can only be mentioned by title, as it were.

I refer to the following: The chronometric longitude determinations in 1849 and 1850 between the United States and Europe; the trans-Atlantic longitude determinations by means of the cable in 1866 and again in 1870; the telegraphic longitude determinations between Greenwich, England, and Brest, France, in 1872; the Labrador eclipse expedition of 1860 and the solar eclipse expedition to Spain in 1870; the part taken by an officer of the Survey in the naval eclipse expedition of 1889 to the West Coast of Africa; the transit of Venus expeditions of 1874 and 1882 conducted by officers of the Survey; the gravity observations made in New Zealand, New South Wales, British India, and Japan by Mr. Smith, the officer in charge of the 1882 expedition, to which was attached Doctor Pritchett, later Superintendent of the Survey; and the work of Mr. Preston, of the Survey, who was attached to the transit of Venus party which went to the Caroline Islands in 1882 and who made gravity observations there and subsequently in the Hawaiian Islands.

Doubtless there are omissions in this brief index of the Survey's international work. It has not been possible to dwell upon the influence which it has exerted on kindred organizations of other lands, any one of which is usually occupied with but one of the many tasks of the Survey.

May the next centennial of this great organization have so satisfying a retrospect as this one affords.

Mr. Jones: We are thankful to Doctor Tittmann for showing us the great value of the part the Coast and Geodetic Survey has played in international matters.

Our next speaker has made astronomy of greater utility by using it for the enrichment of navigation. The endeavor has been made by him,

[1] The American delegate, Mr. Hilgard, was offered but declined the directorship of the Bureau.

and with great success, to elevate navigation to the plane of an exact science and to popularize it, especially in New York City. Ocean tides and currents have been the subject of considerable study by him, and to the former he has contributed privately collected data.

The next address will be "Ocean Tides, with Special Reference to the Work of the United States Coast and Geodetic Survey." I take pleasure in introducing to you Doctor Charles Lane Poor, professor of celestial mechanics of Columbia University.

OCEANIC TIDES, WITH SPECIAL REFERENCE TO THE WORK OF THE UNITED STATES COAST AND GEODETIC SURVEY

Doctor Poor: On the shores of the Mediterranean lived the people whose history, whose philosophy, form the bases of all modern knowledge. In this sea the tides are small and attracted but scant attention. Probably the earliest reference to the tides was Homer's description of a tidal whirlpool, as among the perils encountered by Ulysses:

> Under this, divine Charybdis sucks in black water. For thrice in the day she sends it out and thrice she sucks it in horribly.

It was not, however, until Alexander pushed his conquests throughout Persia to the banks of the Indus, that the oceanic tides were recognized as serious and important phenomena to be studied and explained. A few years later, 325 B. C., Pytheas, who skirted the coast of Europe, from the Straits of Gibraltar to the British Isles, noted the variation of the tides with the varying phases of the moon, and began the difficult study of the tides and their causes.

Thus early was the intimate connection between the tides and the moon recognized, but not until the time of Newton was the reason for this connection known. In the "Principia" he showed that the tides are direct and necessary consequences of the law of gravitation. The moon attracts each and every particle of matter in and around the earth, and the strength of this attraction varies inversely as the square of the particle's distance from the moon. A particle on the surface of the earth directly under the moon will be attracted more strongly than is the earth as a whole, for it is nearer to the moon than the average particle at the center. The moon tends to draw such a surface particle away from the earth, but this lifting force is very small compared with the whole attraction of the earth, and the action of the moon simply lessens the weight of such surface body to a very small extent. This lifting force is not confined to particles directly under the moon, but appears to a greater or less degree upon every portion of the earth's surface.

These forces are extremely small; the loss in weight of a body when the moon is in the zenith is only 1/8,400,000 part; that is, because of the existence of the moon, a 4,000-ton ocean steamer loses 1 pound of its weight when that body is directly overhead. When the moon is on

A 2,500-ton steamer loading at wharf on the Petitcodiac River, at the head of the Bay of Fundy at low tide

A steamer at the same wharf loading at high tide

FIG. 12.—HIGH AND LOW TIDES IN THE PETITCODIAC RIVER

the horizon such a steamer gains half a pound in weight. Again, in an ocean 3 miles deep the greatest variation in weight or pressure due to this attraction of the moon can never be greater than the weight of a layer of water 3/100 of an inch in thickness.

The vertical or lifting force is too minute to produce any appreciable effect; but the waters of the ocean are mobile, and a very small force will cause a particle to move horizontally, whereas a large force is necessary to overcome gravity and to lift it directly upward. A light summer's breeze, playing over the surface of a pond, will cause the water to ripple and form waves; particles will rise and fall, and yet the force of the breeze could not directly lift the weight of the water in the upper portions of the waves. The attraction of the moon causes both a vertical

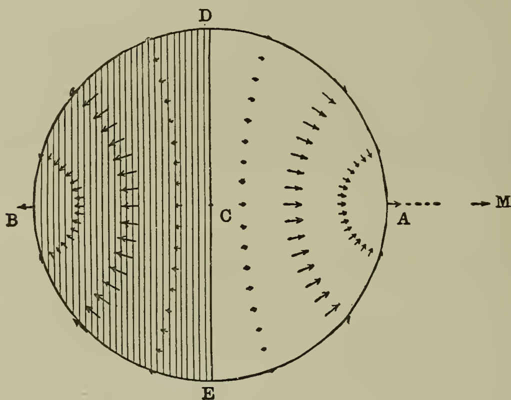

FIG. 13.—TIDE-GENERATING FORCES

and a horizontal tide-generating force, and these two forces are of the same relative magnitude. The vertical portion is not large enough to lift the water against gravity, but the horizontal component, while no larger, is yet powerful enough to move the waters horizontally, and, like the summer breeze, to cause waves in the oceans.

From the time of Newton scientists have attempted to formulate a mathematical theory of the tides. They began by assuming a very simple case—that of a solid, rigid earth, surrounded by a shallow, frictionless ocean of uniform depth; but even this ideally simple problem presented many mathematical difficulties and it was long before it was completely solved.

To pass from this ideal world to actuality, from a simple all-pervading ocean of uniform depth to oceans separated by continents, and varying in depth, defies the skill of the mathematician. Yet Newton, Laplace, and a succession of brilliant scientists have all tried to do this, to pass from the simple to the complex. They consider the tides as a world phenomenon—as an ideally simple wave, modified, broken up, and delayed by the continental barriers, by the varying depths of the oceans. Sir George Darwin considers the great world tides as formed in the broad deep waters of the southern Pacific. From here the tidal wave spreads east and west, around Cape Horn and past Cape of Good Hope, and sweeps through the Atlantic at a rate depending solely upon the depth of the water. The wave is about 40 hours old when it reaches the eastern coast of the United States and nearly 60 when it arrives at London and ports on the North Sea. "It is interesting to reflect that our [British] tides to-day depend even more on what occurred yesterday or the day before in the southern Pacific and Indian Oceans than on the direct action of the moon to-day."

This simple world idea of the tides was evolved and elaborated from observations of the tides of Europe. In the days of Laplace there was little knowledge of the tides in other parts of the world, and it was naturally thought that the European tides were fairly representative. The dynamical or world wave theory fitted and explained the simple tides, and thus became the basis of all tidal work and theories. Later the tides in the Pacific and Indian Oceans were studied and were found to differ greatly from those of Europe; in fact, the tides of the North Atlantic are exceptional in their simplicity. Yet, as each new complication was found it was explained away, as a modification of the general grand wave, due to some local condition. The theory that the tides are a world phenomenon has the support of the world's greatest mathematicians and all the prestige their names can lend.

Certain investigation of the Coast and Geodetic Survey would indicate that this theory may not be the correct explanation of the oceanic tides. During the century of its existence this body of skillful observers and able investigators has collected and discussed an enormous amount of tidal data in both the Atlantic and the Pacific Oceans. As these observations were collected and brought together discrepancies were found. The tides of one port could not be fitted into and made to harmonize with the tides of another place. A few such discrepancies would be explained as modifications of the general tidal wave, but as observations were increased in number discrepancies multiplied, and to fit all conditions the general tidal wave would have to writhe and squirm and change its form and character from place to place until it lost all semblance of a single uniform progressive wave. Gradually there has been evolved the feeling that the tides are not a world phenomenon but are strictly local in character and in being; that the tides of the Atlantic Ocean are due to oscillations in the waters of the Atlantic independent of what has or may happen in the waters of the Pacific.

This idea of the tides as purely local phenomena, as opposed to the theory of a grand earth-wide wave, was perhaps first glimpsed by William Ferrel. In his tidal researches, published by the Survey in 1874, he attributed the great size of the North Atlantic tides to the fact that a canal running from Europe to America and closed at both ends would have a free period of oscillation approximately equal to a half lunar day. The later researches of Doctor R. A. Harris elaborated this idea and developed a thoroughly consistent theory of the tides as local phenomena.

Each body of water, large or small, has its own period of vibration, the length of time required for a long free wave to travel forward and back across its surface. Take a rectangular shallow tray of water, for example. If one end be suddenly raised and immediately lowered again, a long wave will be started, which runs to the other end of the tray, is reflected, and returns to the starting point. The wave again sets out and continues to run back and forth, growing smaller and smaller until the water gradually returns to rest. The length of time taken by the wave in one complete journey to and fro across the tray is the vibration period, and this period depends upon the length of the tray and the depth of water. In a lake 100 miles long and 200 feet in depth the wave, traveling about 55 miles per hour, would require something less than four hours to complete its journey. The North Atlantic Ocean is some 3,000 miles wide, yet it is of such an average depth that a free wave travels at a rate of some 500 miles per hour. The wave requires, therefore, 12 hours to pass from Europe to America and return, and thus its complete period of oscillation is some 12 hours.

Now, the tide-generating forces disturb the water in a lake or the ocean and give rise to a wave, and exactly 12 hours later this disturbance is repeated. The waters are thus subjected to regular periodic shocks, and the intervals between these shocks are independent of the size or shape of lake or ocean; the intervals depend solely upon the motion of the moon. In a narrow lake or inclosed sea near the equator the natural period of which is much less than 12 hours, waters will rock back and forth in unison with the force, the surface of the water being always normal to the direction which a plumb line takes under the action of the disturbing forces. In a long lake or canal—one so long that it would require over 12 hours for a free wave to travel back and forth across the surface—the water will oscillate with the period of the force, but the oscillation will be inverted. The oscillations will be of the same character as in the small lake, but the time of high and low water will be changed. The surface of the water is not normal to the plumb line. If the canal were exactly one half-wave length long, it would be high water at the eastern end when the moon crossed the meridian of the middle point of the canal and high water at the western end six lunar hours later.

If the natural or free period of oscillation of the lake or ocean be exactly equal to the period of the tidal forces, what then? The oscillations of the water would grow greater and greater without limit; each succeeding tide would be higher and higher, until the waters would so overflow the banks of the lake or ocean as to alter the character of the oscillation; that is, long before this disruption could take place the waves would be so large that forces and conditions hitherto neglected would be brought into play and modify the simple results. When the oscillation becomes large the resistance offered to the motion of the water particles would eventually become sufficient for preventing the tidal forces from further augmenting the oscillation. While thus the tides can never really become infinite, even if at the start the two periods are exactly identical, yet they may become very large.

When the period of free oscillation of an ocean is very nearly equal to the period of the tidal forces, the tides may, for this reason, be considerably larger than they would if the two periods were radically different. The North Atlantic, from Europe to America, has a period of about 12 lunar hours for a complete oscillation, and to this has been ascribed the abnormally large semidiurnal tides.

So far we have discussed simple oscillations, or standing waves, in comparatively narrow canal-like bodies of water; but the lakes and oceans of the earth are irregular in shape and of varying depth. They are all comparatively wide, and this very width introduces complications. The vibrations of a wide lake are extremely complex as compared to those of a narrow canal of the same length. In fact, a complete mathematical solution of the character of the vibrations of such a lake is impossible; but the general type of the oscillations is known. Under the action of the tide-generating forces the surface of a circular lake, for example, rocks about a "no-tide" point. Imagine a circular disk of cardboard, such as a dry compass card, resting on a central pivot and so weighted at one point that the surface is not quite horizontal. The highest point of the circumference will represent high water and the lowest point low water. Now turn the card slowly around the pivot and the line of the high and low waters will successively take up all directions, the high point always being directly opposite the low point. When the high point is to the eastward of the pivot the low point will be to the westward; when the high is to the north the low will be to the south. Further, the height above the pivot of any intermediate point on the line of high and low water will depend upon the distance of that point from the center of the card. A point halfway out toward the circumference will be only one-half as high above the pivot as the point on the edge. Thus, in this imaginary illustration, it would be high water at all points due east of the pivotal, or no-tide, point at the same instant, but the height of the tide would increase with the distance from the central point. Now, a line, which connects all these points at which it is high water at the same instant, is called a "cotidal" line, and on our imaginary card all the cotidal lines would be straight and would radiate from the pivot, like the spokes of a wheel; the lines of equal rise and fall would be concentric circles or ellipses with the pivot as common center.

In the case of a deep lake the tidal oscillations of its surface are very similar to the rotating card. As the size of the lake increases, the cotidal lines still radiate from a no-tide point, but they become slightly curved; the lines of equal rise and fall become somewhat more complicated in form than the system of concentric ellipses which constitute such lines for the small body.

If the oscillations of a simple deep lake are so complicated, it is easy to see that those of an irregular-shaped ocean must be extremely complex. In general, however, when such an irregularly shaped surface is set into periodic vibration, it breaks up into component parts, each part vibrating by itself. Most of the ocean's surface is covered by one or more such systems. The number of the systems and the location of the nodal lines or points will vary with the period of the vibration, or with the length of the wave. When the wave length is short as compared to the dimensions of the vibrating surface, then the area can oscillate in an infinite number of ways, but when the length of the wave is of the same order of size as the dimensions of the surface, then the division is simple and the nodal lines few.

Now, the tidal forces have a period of 12 hours and the wave length of the corresponding vibration in the deep waters of the ocean is from 5,000 to 6,000 miles. The areas in the ocean which vibrate in this period will, therefore, be comparatively few, and it is not impossible to locate them approximately. In these areas the vibrations will be large and the resulting tides considerable, for the free period of each approximates closely to the period of the forces. The tides in each area are caused by the oscillations of the waters in that area; they are to a great extent independent of the tides in an adjacent area. The tides are local phenomena.

The character of the oscillation and of the tide in each area is largely determined by its lateral boundaries. Gradually shoaling water or converging shore lines will increase the height of the tide, and such difference in the shore lines determine whether the eastern or the western end of the area shall have the greater rise or fall. It may so happen that the tide at one point is considerably higher than at others, and in such cases the wave there generated may be propagated as a free wave and travel across adjacent areas, modifying to a greater or less extent the individual tide of that area.

The North Atlantic forms a rough trapezoidal basin, the West Indies and the northeastern coast of South America forming one side; a line running from Cape St. Roque to Cape Finisterre in Spain and touching the western coast of Africa on its way forms a second side; the third side extending from Spain to Ireland, thence to Iceland and Greenland; the fourth side being formed by the coast of America from Greenland to

Florida. This area breaks up into three vibrating zones, the first of which takes in all that portion of the ocean which lies north and east of a line joining Newfoundland with the Cape Verde Islands and the Coast of Africa. This area is about one-half wave length long and oscillates

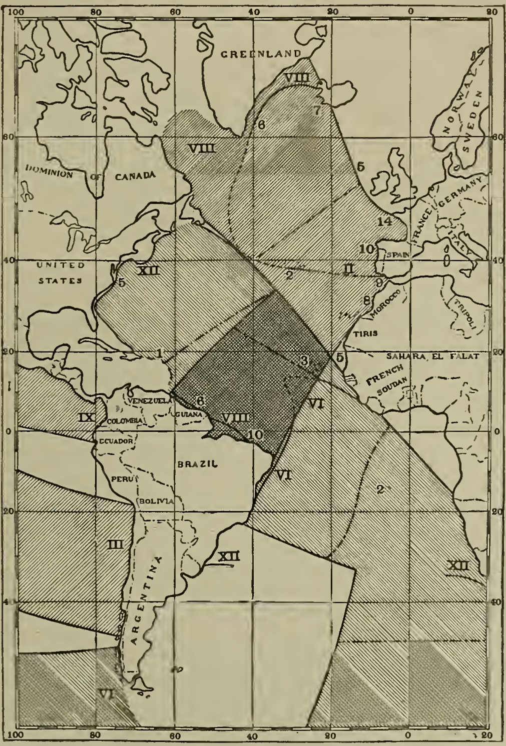

FIG. 14.—THE OSCILLATORY AREAS OF THE NORTH ATLANTIC

The Roman numbers (XII) indicate the times of high water; the Arabic numbers (5) show the mean rise and fall of the tide

about a nodal line extending from the banks of Newfoundland to the northwestern coast of Ireland; the high tides at Greenland will be six hours later than the tides on the coast of Africa or Spain. The second area joins this first at right angles off the coast of Africa and forms the shorter arm of a broken cross, the coast of South America being the southern boundary. This vibrates in unison with the first area, about a nodal line extending northwesterly through the middle of the ocean. It will be high water, therefore, on the coast of Brazil at the same time as at Greenland, and at the juncture of the two areas, off the coast of Morocco and Portugal the range of tides should be considerable. This great range of tides creates a free wave which travels northward along the shores of France and Great Britain, modifying and increasing the pure oscillating tides of those regions.

The third area extends from the United States to the Cape Verde Islands and overlaps the second. This area oscillates about a nodal line extending in a northeasterly direction from the West Indies to the middle of the Atlantic near the Azores. It will be high tide along the American coast at the moment of low water at the eastern boundary of the area, and from the coast of Newfoundland to the shores of Florida high and low waters will occur at the same absolute moments.

The tides in the area covered by the two oscillating systems will be confused and the times of high and low water will be intermediate between the times due to each system by itself.

Now this explanation of the Atlantic tides as being due to vibrating motions of more or less definite areas agrees fairly well with the actual conditions. Tidal observations are confined to the coasts and to outlying islands; no data are at hand for drawing the cotidal lines or for determining the range of the tide in the middle of the ocean. The high tides on the coast of Brazil occur at the same time as do the tides on the coast of Greenland and Iceland, while the tides of Morocco and Spain are six hours earlier. Again, there is an abrupt change in the cotidal lines off the Banks of Newfoundland, and there is some evidence of the existence of the nodal line off the coast of Ireland. In the southern area, on account of the overlapping systems and of the adjacent area of the South Atlantic system, the nodal line is almost completely obliterated.

Fortunately there is a way in which this new tidal theory can be tested. If the world wave theory of the older mathematicians be true, and the tides originate in the Pacific and Indian Oceans, then "springs" should occur in those oceans some 40 hours earlier than in the northern Atlantic. The interval between the conjunction of the sun and moon and the occurrence of springs at any point should show a regular progression from the Pacific around Cape Horn and up the Atlantic seaboard. Yet no such progression is found. Spring tide occurs along our coast from Halifax to Old Point Comfort almost simultaneously with springs in the Indian Ocean, nearly 14 hours before springs at Cape Horn and the Cape of Good Hope, and over 60 hours before that at Melbourne. Along the Pacific coasts of North and South America the time of springs shows not the slightest trace of progression. The entire coast seems to be broken up into four or five regions in each of which the time

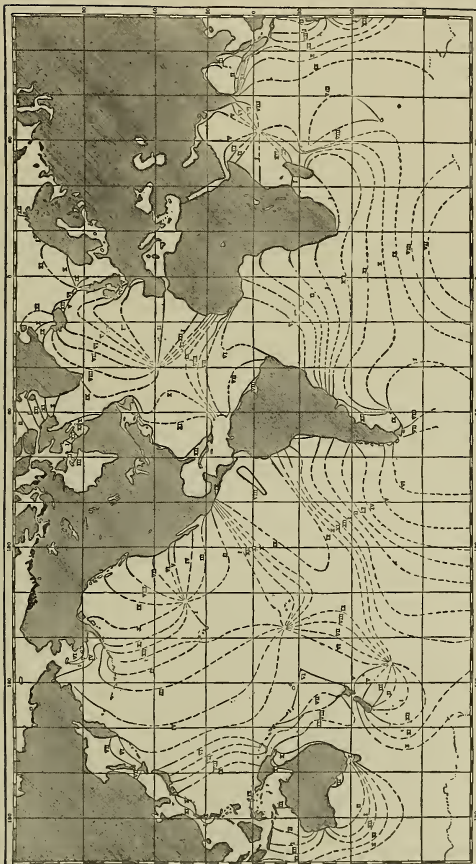

FIG. 15.—COTIDAL LINES OF THE WORLD

of springs is approximately the same for all points, but in passing from one region to another the time changes abruptly. Thus, both the Atlantic and Pacific Oceans seem to be broken up into independently vibrating areas, and the weight of evidence would seem to be in favor of the new theory that the tides are local in their origin.

This explanation of the tides as purely local phenomena stands out as the great scientific contribution of the Coast and Geodetic Survey to the theories of the oceanic tides.

Mr. Jones: We thank Doctor Poor for his very interesting and constructive discussion on tides.

The Coast and Geodetic Survey is essentially a geographic organization, and while much of its work is the delineation of the boundaries between land and water areas, the Survey has made other contributions in the broad field of physical geography. We are very fortunate in having with us one eminently qualified to tell us something of this work. Our next address, and the last, will be "The Contribution of the United States Coast and Geodetic Survey to the Science of Physical Geography." I take pleasure in introducing to you Doctor Douglas Wilson Johnson, professor of physiography of Columbia University.

THE CONTRIBUTIONS OF THE UNITED STATES COAST AND GEODETIC SURVEY TO THE SCIENCE OF PHYSICAL GEOGRAPHY

Doctor Johnson: A geographer labors under an inevitable embarrassment in addressing you at the end of a program in which so many distinguished speakers have paid tribute to the contributions made by the United States Coast and Geodetic Survey to their respective sciences. The field of physical geography is so broad it overlaps its sister sciences at many points; and where such overlapping occurs, my friends in the other sciences and I must stand on common ground when acknowledging our mutual debt to the splendid organization which has made us all the richer. It is not feasible adequately to express the obligation under which all geographers have been placed by the high achievements which we celebrate to-day without duplicating words of appreciation to which you have already listened. I crave your indulgence, therefore, if in speaking for my coworkers in the science of earth relations I again touch briefly on some phases of the Survey's work which have been more fully presented by others.

Should it appear in what I have to say that physical geography lays claim to too large a portion of the great field of human knowledge, I can justly plead in defense that I have nowhere transgressed those limits long accorded to the subject by honorable tradition. Four great divisions of the science are commonly recognized, the first of which concerns itself with the broader relations of the earth as a globe, including its size, shape, motions, and magnetic properties. The physical geography of the atmosphere treats of the composition, temperatures, movements, and other phenomena which characterize the gaseous envelope of the earth; while the physical geography of the ocean does not stop with a consideration of the corresponding elements in the liquid envelope, but includes, in addition, a study of the form and composition of the ocean bottom. The physical geography of the lands is concerned with the evolution of the surface features of the globe under the influence of rivers, glaciers, waves, and winds. Truly the scope of the subject is sufficiently broad to satisfy the most ambitious.

But if the boundaries of geographic science are far extended, the activities of the Coast and Geodetic Survey have been no less far-reaching. Beginning their labors along that line where land and air and ocean meet, its hardy pioneers have carried their researches forward to the ocean deeps, backward over the continents, and upward into the realm of the winds. And finally, not content with pushing back the limits of the unknown in these three directions, Hayford and his collaborators have recently embarked in the one direction yet remaining, seeking isostatic equilibrium 76 miles below the planet's surface. Of the Coast and Geodetic Survey it may truly be said that its field of study includes quite literally the heaven above, the earth beneath, and the water under the earth.

Let us turn for a moment to that branch of physical geography mentioned first above, and ask the question "What contributions has the Coast and Geodetic Survey made to our knowledge of the earth as a globe?" To come within the limits of allotted time, the answer must be brief; but there are several items which no geographer would care to have omitted from even the briefest catalogue of the Survey's honorable achievements in this department of our science.

More than 200 years before Christ, the Alexandrian astronomer and geographer, Eratosthenes, introduced a method for measuring the size of the earth, which gave him approximately correct results. This method consisted in measuring over the curved surface of the earth the length of an arc connecting two points, the positions of which were determinable; and is to-day, more than 2,000 years later, the only known means of ascertaining with accuracy the dimensions of our planet. The longer the arc measured, and the more refined the instrumental methods employed, the greater will be the degree of precision attained. The vast extent of our national domain offered the Survey an exceptional opportunity to repeat on a grand scale the work of the ancient Alexandrian. Arcs which are hundreds, in some cases even thousands, of miles in length have been measured across our portion of the globe's surface. From the Atlantic to the Pacific Ocean along the thirty-ninth parallel, from Canada to Mexico along the ninety-eighth meridian, and again along the Pacific coast, from Maine to Florida along the Atlantic coast—run a few of the great arcs already completed by the Survey, giving us a total of some 12,000 miles, or nearly half the circumference of the earth, measured by primary triangulation. The data thus secured have been utilized in making new computations of the earth's magnitude. Nor was the Survey content to secure its results by using methods and instruments just as these were inherited from earlier workers. On the contrary, both methods and instruments have been improved and perfected until the geographer's present knowledge of earth dimensions has a degree of precision undreamed of by the pioneers in this branch of mensuration.

Closely connected with the study of the earth's dimensions is the study of the form of the earth. The geographer is no longer content with proofs of the nearly spherical form of the earth adduced by Eudoxus and Aristotle before the Christian era; nor yet with proofs of the oblateness of the spheroid secured by French savants near the middle of the eighteenth century. Modern investigators have shown that in its actual form the earth departs very materially from the theoretical oblate spheroid, the sea-level surface, together with its imaginary extension under the continents, being a surface which now rises above, now falls below, the *mean* surface of the earth by amounts reaching hundreds of feet in places. The present form of the *geoid*, as this very irregular sea-level surface is called, is a matter of interest to the geographer, since its irregularities deflect the plumb line from the direction normal to the spheroid, and so introduce errors into astronomic determinations which can only be eliminated after numerous observations have fully established the direction and amount of the disturbing force. It is to the credit of the Coast and Geodetic Survey that its computations of both the size and form of the earth are probably the most accurate which have ever been made, partly because in making them the theory of isostasy was consistently applied.

The regular rotation of a globular earth made possible the system of parallels and meridians upon which the geographer depends in locating points upon the curved surface of the planet. The accurate determination of the latitude and longitude of places requires the skill of such experts as have reflected honor on the hundred years of the Coast Survey's activity. The method of determining longitude by telegraph was introduced and perfected by the Survey, and later adopted by all other civilized countries, with whom it became known as the "American method."

At the present time it is practicable to ascertain the longitude of a point in the United States with a probable error of not more than 10 or 20 yards, while latitude determinations may be made with a probable error only one-fifth as great.

A physical property of the earth, possessing a high degree of importance for the geographer, is its magnetism. Whether employed by the mariner steering his course through storms at sea, the explorer guiding his footsteps in a new land, the aviator cutting his path through mist and cloud, or the surveyor determining the position of a railway route, the magnetic needle is a servant of priceless value, and any force which affects it is a matter of prime interest to the physical geographer. Because the needle does not usually point to the true north, and because the amount of its declination from that direction varies from year to year, and even from hour to hour, the physical geographer must acknowledge his indebtedness to any organization which investigates the several elements of the earth's magnetism, records the changes to which those elements are subject, discovers the laws which govern such changes, and charts the results obtained for the profitable use of the world.

I need not dwell upon the important work done by the United States Coast and Geodetic Survey in the field of terrestrial magnetism. One peculiarly well qualified to speak with authority concerning any matter touching the magnetic properties of our globe has already paid tribute to the Survey's honorable record in this important field; and it is fitting that I confine myself to a simple expression of the geographer's sense of obligation for the Survey's valuable contributions to this department of scientific knowledge.

One of the physical properties of the globular earth having far-reaching geographical consequences is the vertical downward pull to which bodies on its surface are subjected by the force of gravity. Two centuries and a half ago it was discovered that this gravitative pull was not everywhere of the same strength, since a pendulum clock lost time when moved toward the Equator. The demonstration that this variation in the force of gravity was due to the earth's departure from a truly spherical form opened up a wide field for the study of earth form through measurements of gravity by pendulum observations. The record of the Coast and Geodetic Survey in this field of research is truly an enviable one. In order to achieve the highest possible degree of accuracy the Survey designed and constructed a special form of pendulum, the Mendenhall pendulum, which has given excellent results. Some conception of the delicacy of this instrument may be gained from the fact that a correction is applied for the effect of the pendulum in rocking its 100-pound brass case even when swinging slowly through a very small arc, the slight movement of the case being detected by means of an interferometer capable of measuring distances as small as one ten-millionth of an inch.

Exceedingly small variations in the intensity of gravity are susceptible of detection with a pendulum of this type, and when corrected for the disturbing effects of altitude, variable topography, and other interfering causes, give us the means of deducing the form of the earth with great exactness. Reference has already been made to the utilization of the Survey's gravity observations in developing the Hayfordian theory of isostasy; and while the problems of isostasy claim the attention of the geologist more fully than that of the geographer, certain aspects of physical geography, such as the conditions under which peneplanes are developed and later uplifted, are closely related to the theory of isostatic compensation; and Hayford's work has made a profound impression upon all geographers.

Without attempting to present anything like a complete list of the contributions made by the Coast and Geodetic Survey to that branch of physical geography which we have just been considering, I ask you now to turn your attention for a moment to a phase of the subject in which it might well seem the Survey could scarcely have interested itself. The physical geography of the atmosphere could not, perhaps, rightly claim the service of a coast survey in enriching its special field of learning. Yet even here the geographer must gratefully acknowledge his indebtedness to an organization whose interests have been of truly astonishing breadth. We may note in passing that the Survey has contributed to our knowledge of atmospheric electricity, atmospheric refraction, and the influence of the winds upon water levels; but more important is the fact that for 15 years the Survey claimed as one of its members a great American meteorologist, William Ferrel, who in the years 1875 to 1881 published in the Survey reports a series of valuable monographs under the general title "Meteorological Researches." Through these contributions the Survey rendered to the physical geography of the atmosphere a service of enduring value.

If we turn to the physical geography of the lands, the contributions made by the Coast and Geodetic Survey to our knowledge of land forms are most imposing. In the first place it should be noted that the geographer must depend upon maps for the representations of those areas which he desires to study, and that the best of our maps are located and bounded in accordance with data furnished by the Coast and Geodetic Survey. It is a source of gratification to the geographer that one great national bureau is charged with the duties which in the hands of the several States would inevitably lead to that confusion which reigned in Australia until, in 1912, the several surveyors general united in recommending the establishment of a single survey, modeled after the Coast and Geodetic Survey of the United States. The consequences of individual State control, which would result from lack of uniform standards of accuracy and lack of agreement with work in adjoining States, may be imagined from the fact that "the best maps of the States of Ohio, Indiana, and Kentucky, constructed upon independent data, when put together leave no delineation of the Ohio River," while "between the land-survey maps of Illinois and Missouri the Mississippi River presents in places wide lakes, while in others it entirely disappears." The Coast and Geodetic Survey has not only furnished all the States with uniform and precise data upon which to base their local surveys, but has assisted many States in defining the geographical boundaries which separate them from their neighbors, and has cooperated in a similar manner in establishing parts of our national frontiers.

To the Coast and Geodetic Survey the geographer is likewise indebted for a great series of precise levels established throughout the country and utilized by the topographers of the United States Geological Survey in constructing contour maps. The careful determination of the true sea level with the establishment of numerous points at accurately determined altitudes above that level also offers an opportunity for future investigators to solve the problem of possible elevations or subsidences of the land. It is due to the Coast and Geodetic Survey's accurate determinations of the mean sea level at Sandy Hook and at Fort Hamilton in past years that it has been possible to prove the absolute stability of the Atlantic coast in the vicinity of New York during a period of at least a quarter of a century. In a somewhat similar manner the precise location of points on the earth's surface affords a basis for the detailed study of those lateral movements of the crust sometimes associated with seismic phenomena. Thus, following the San Francisco earthquake, a resurvey of points previously established by the Survey demonstrated the magnitude and character of the lateral displacement.

The student of land forms finds in the charts of the Coast and Geodetic Survey a wealth of valuable material. Indeed, if you ask a group of geographers what constitutes the most important contribution of the Survey to geographical science, a majority will answer: "The charts." It is true that only a narrow margin of the land is represented; but it is a zone of peculiar importance, a zone where two great physical provinces meet, and a zone where changes in the form of the land take place with exceptional rapidity. Moreover, the Survey's delineation of this important zone has been achieved with rare skill. Where else will you find such admirable representations of a series of wave-eroded terraces as may be found on the Survey's charts of the California coast? Where is the past history of a complicated shore line and its gradual evolution to the present form recorded with such fidelity as on the Survey's charts of Nantasket Beach, on the coast of Massachusetts? Where else than on the Survey's chart of Cape Canaveral can the varying position of a shifting cape be so well studied? The essential features of bars and spits, inlets and lagoons, capes and deltas recorded on the charts of the Survey make them an invaluable addition to the world's cartographic library of land forms.

Geographers derive a special profit from the Survey's system of revising from time to time the charts of such portions of the shore as are subject to exceptionally rapid changes. The student of shore forms is thus put in possession of data which enable him to trace the recent evolution of the shore line with certainty, and to draw conclusions as to its past history with an unusual degree of assurance. From such data the laws controlling the operation of shore forces may be discovered and hence the interpretation of shore forms in other regions greatly facilitated. That the shore-line changes recorded by successive charts are by no means of minor importance may be appreciated from the fact that Fishing Point, on the Virginia coast, has grown southward more than 3 miles in 65 years, converting a region of open water into a natural harbor of refuge. Monomoy Island, on the Massachusetts coast, has gained 3 miles at its northern end in the same interval of time. At the entrance to New York Harbor successive surveys show the westward growth of Rockaway Point at a rate of 250 feet per year, while Long Beach, Coney Island, and Sandy Hook have also advanced toward the harbor entrance.

Other parts of the coast are losing ground under the persistent attack of the waves, which may cut back the land so rapidly as to undermine and destroy houses along the shore. Sand bars separating shallow lagoons or bays from the open ocean are broken through during storms, and the lateral migration of inlets formed in this manner are clearly shown on successive series of the Survey charts.

Much light is thrown on the history of rapidly changing land forms of nonmarine origin, when these occur in the narrow coastal zone covered by the topographic work of the Survey and when successive charts of such a region are available. The Bogoslof Islands, on the Alaskan coast, furnish an admirable example of shores changing with great rapidity under the influence of volcanic forces, while the activity of a river in adding a new lobe to its delta is beautifully shown on charts of two successive surveys at the mouth of the Mississippi River.

It is in connection with the physical geography of the ocean, however, that the United States Coast and Geodetic Survey has probably rendered its most signal service to the science of geography. The Survey's notable explorations of the Gulf Stream have served to acquaint the geographer with the principal characteristics of that most important of all ocean currents; and the famous investigations of Pillsbury, the work of the Survey's ship *Blake*, under the command of Sigsbee and Bartlett, and the results secured by Bache, Pourtales, and others must always fill an honorable page in any history of the Survey's operations. Our knowledge of the ocean has been further advanced through the Survey's deep-sea soundings, carried on in part with the aid of a special sounding machine designed by Sigsbee, and through its observations of oceanic temperatures and its determinations of the salinity, density, and composition of sea water. Studies of current action on the dangerous Nantucket Shoals, in and about New York Harbor, and along many other parts of our coast occupy an important place in the Survey's reports. Ferrel's studies of tides and the monumental work on tides which has made Harris an international authority in his chosen field are but two out of many valuable contributions which the Survey has made to this branch of oceanography. To the Survey we are also indebted for the development of a tide-predicting machine, representing a marked improvement over any other similar device ever constructed.

The form of the ocean bottom, particularly near the margins of the lands, has claimed a large share of the Survey's attention. That this is eminently appropriate must appear from consideration of the fact that the hidden irregularities of the sea bottom constitute a menace to navigation which can only be avoided when carefully located and accurately charted. Parts of the ocean floor are veritable graveyards of ships in which rocky pinnacles are the tombstones bearing the names of the vessels which met disaster on their submerged points. The geographer profits from the wealth of detailed information concerning the ocean bottom which the Survey develops in the course of its efforts to render navigation in the shallower waters safe; and while the composition and distribution of the materials composing the submarine floor are to him a matter of no small importance, his primary interest, like that of the Survey, is in the form of the submerged surfaces.

By developing the contours of the underwater areas the Survey enables the geographer to carry his study of land forms beyond the barrier of the shore line. The ridges and valleys of the Maine coast are only partially exposed above sea level. No study of them can be complete which does not consider their seaward continuations as revealed by the coast charts. The drumlins of Boston Harbor have been greatly eroded, but the charts of that region reveal submerged platforms representing the bases of hills now consumed by the waves. Off the south coast of New England the course of the great terminal moraine of the continental glacier can be traced beneath the ocean waters, while the visible valley of the Hudson may be followed as a submarine canyon to the edge of the continental shelf. Any investigation of the origin of the Carolina Capes or Cape Canaveral requires a study of the shoals which lie beyond these projecting points, and which are clearly shown on the Survey's charts. The studies of the Florida reefs and keys, made by Agassiz and others, supplemented by the excellent charts of those interesting coral formations now available, enable the geographer to visualize an important section of our continental margin of which but little is revealed to the ordinary eye. A knowledge of the subaqueous contours of the Mississippi Delta is essential to a proper understanding of that small portion of the delta projecting above the Gulf waters, while the submerged valleys off the California coast have been used in developing a theory of the physiographic history of the Pacific border of the continent. The Alaskan fiords are incompletely known until the work of the Coast and Geodetic Survey establishes the contours of their deeply submerged portions—a work carried on with such skill that successive halts in the retreats of the ice tongue which carved a given fiord are demonstrated by the discovery of submerged terminal moraines, revealed by means of the sounding line.

But it is not usually the larger features just mentioned which prove the greatest danger to navigation. A submerged bowlder or pinnacle rock is a more serious menace, because more difficult to locate. Imagine, for example, that one of the great glacial bowlders of the New England coast lies concealed somewhere beneath the treacherous surface of a broad, smooth sea, and that you must discover it by repeated soundings; or that a whole field of such bowlders, frequently visible on glaciated lands, may likewise be covered by a shallow sea. Clearly the task of locating and charting these hidden dangers to shipping imposes an almost impossible burden on the man with the sounding line. On the Alaskan coast sharp rock pinnacles or needles frequently rise abruptly from the sea, and occasionally attain a height greater than that of the Washington Monument. Similar pinnacles in the submerged portion of the fiords fail to reach the surface but rise high enough to wreck a passing steamer. Imagine yourself sounding many square miles of fiord waters in the hope of dropping your sounding lead on the topmost point of a submerged pinnacle of this type. Would it surprise you if, after years of the most painstaking labor, a vessel should strike and sink where the chart showed deep water?

One of the most interesting advances in the Survey's method of charting the bottoms of shallow seas consists in the perfection of a wire drag adapted to work in tidal waters, by means of which detailed features of the ocean floor may be more readily discovered and charted. A wire, sometimes more than 4 miles in length and supported by suitably spaced floats, is dragged through the water at any desired depth until some hidden obstruction is encountered. By means of wire-drag surveys, as many as 15 danger points have been discovered in a single day's work. In waters so extensively used as the East River at New York, rock projections capable of wrecking vessels of the present maximum draft were last year discovered by the wire drag at a spot where previous surveys showed no such danger. When an obstacle has once been definitely located by the drag, its exact form may be developed by repeated careful soundings, while the drag continues its sweeping operations.

It will be evident that such refined work must add much to the geographer's knowledge of the sea floor. Even the scattered morainic bowlders of a submerged glaciated area are thus revealed, and the glacialist may draw conclusions supplementing those based on observations above sea level. Projecting masses of coral may be located and a more adequate picture of the reefs on which they grow thus made possible. Employed in combination, the wire drag and sounding methods have produced results of a truly remarkable character. Through the use of one method or the other, or of both methods combined, the Survey has been enabled to report on the character of submarine springs, mud lumps, bowlder fields, giant sand ripples, fissures, dikes, and many other minor features of lands now submerged. Successive surveys of the same area have demonstrated the filling and scouring action of tidal currents and the changes in sea-floor level associated with seismic disturbances.

I have made no attempt to catalogue in full the many valuable contributions which the United States Coast and Geodetic Survey has made to the science of physical geography. I am only too sensible of the fact that I have omitted from this brief summary items which others would have wished to see included; but my object has been to indicate the general scope of the debt geographers owe the Survey, rather than to itemize the full account of our indebtedness. It would be improper, however, to close this address without saying at least a word of appreciation for another of the Survey's contributions to geographic science, which it is more difficult to describe in words but which no geographer can fail to recognize. I refer to the influence exerted upon our science by the high standards of accuracy and the reputation for progressive efficiency which the United States Coast and Geodetic Survey enjoys throughout the world. As one noted geographer has well said: "The Survey has been a concrete embodiment of the fact that geography is not merely a descriptive science, but is capable of being reduced to a high degree of mathematical accuracy in many of its branches."

Mr. Jones: We are very grateful to Doctor Johnson for this highly illuminating and interesting address on physical geography.

On account of the many requests and through the further courtesy of the Secretary of the Smithsonian Institution, our exhibit in this building will remain open to the public on Friday, Saturday, and Sunday during the regular hours that are observed by the Smithsonian Institution.

And now in behalf of the Coast and Geodetic Survey, I thank the gentlemen most heartily who have contributed to the great success of these exercises. I am sure what they have said will act as an inspiration to all of us in the continuation of the work so nobly begun.

THE CENTENNIAL BANQUET, FRIDAY EVENING, APRIL 6, 1916

OPENING ADDRESS OF THE TOASTMASTER

Mr. Jones: Mr. President, Mr. Minister, ladies, and gentlemen, it affords me especial pleasure to extend to you on this occasion a hearty welcome on behalf of the members of the United States Coast and Geodetic Survey. I know I may extend a cordial greeting to those who have traveled many miles to join with us in this centennial celebration.

One hundred years is a long span to be given to one line of service. Fifty years, even 25 years, might be considered fairly concentrative work. Our country was young when the necessity for charting its coast was recognized, and the Bureau—the oldest scientific establishment of our Government—which was called into being by the wisdom of President Jefferson and the genius of Professor Hassler in 1816, has accomplished work of which we may justly be proud.

This history, which we have spent the last two days in reviewing, brings to light the record of men, fine and true, of patriotic ideals and character, who have spared nothing in their labors for the advancement of science and the safety of mankind. I gladly join, with the utmost enthusiasm, in the felicitation of those who have done this good and effective work.

When President Jefferson conceived the idea of the United States Coast Survey he called on a learned scientist from Switzerland, Professor Hassler, to aid him. Professor Hassler planned and directed this work for years. It seems peculiarly fitting, therefore, that we should at this centennial celebration again have with us a representative of that country. I have the honor of introducing to you His Excellency Doctor Paul Ritter, the minister from Switzerland.

ADDRESS BY PAUL RITTER, LL. D., ENVOY EXTRAORDINARY AND MINISTER PLENIPOTENTIARY FROM SWITZERLAND

Doctor Ritter: Mr. President, Mr. Superintendent, ladies, and gentlemen, it may surprise some of you that the only foreigner who has the privilege to say a few words on this festive occasion is the Swiss minister. Needless to state there is no foundation whatsoever for the facetious suggestion that profound political reasons governed the choice of the representative of the only country which has no coasts, no harbors, and no navy to assist in this jubilee celebration of the United States Coast and Geodetic Survey.

I owe my presence here to the circumstance which is alike honorable and agreeable to me, that the first Superintendent of the Coast Survey, which now has grown so great and celebrated, was the Swiss engineer, Ferdinand Rudolph Hassler.

At all times in the history of the United States some of my countrymen may be found who assisted in the development of this country and who have made a place for themselves in the hearts of grateful Americans.

The activities of Professor Hassler, as founder of two of your great national enterprises—that is, the Coast Survey and the Bureau of Standards—took place in the first half of the nineteenth century. A retrospect shows us that during those 50 years my countryman had as contemporaries several distinguished Swiss, who emigrated to this country at about the same time. First among them, it gives me particular pleasure to mention Hassler's friend, Albert Gallatin, of Geneva.

Actuated by the same spirit as Lafayette, Gallatin, at the age of 18, crossed the ocean in order to fight for American independence. Later on he achieved the highest honors open to a Swiss in this country. He was not only the first foreign-born Senator of the United States, but for 12 years he served with acknowledged ability and success as Secretary of the Treasury under Jefferson and Madison. He went to England with John Quincy Adams as a peace commissioner and remained abroad until 1823 as minister to Paris. After his return he declined the offer of the Democratic Party to become a candidate for the Vice Presidency, because he wished to devote all his time to his scientific studies of finance, history, and ethnology.

Not less well known to you, gentlemen, is the name of the Swiss naturalist, Louis Jean Rudolph Agassiz, of Motier, who during the 27 years of his incumbency made famous the chair of zoology at Harvard. His son, Alexander Agassiz, who was born at Neuchatel in 1833 and who labored in the same field of research at Harvard as his father, was at one time an aid in the Coast Survey, with which he remained closely associated, as shown in his book, "Three Cruises of the Blake." A very special reason for mentioning his name is that he was so highly esteemed by President Cleveland that the latter offered him the superintendency of the Survey, but Agassiz preferred to continue his favorite researches.

Another name highly esteemed in the United States is that of my countryman, A. Henry Guyot, of Neuchatel, a friend and collaborator of Louis Agassiz and an authority on geology and physical geography. For 30 years he was professor of physical geography at Princeton. When he died, in 1884, his students sent for an erratic bowlder from a Swiss glacial moraine, and with suggestive sentiment they marked his American grave with that memorial stone from the land of his birth.

It may be mentioned casually that the best-known investigators of the aborigines of the United States, most profoundly familiar with the

Indians and their languages, are Albert Gatschet, of St. Beatenberg, and Adolf Bandelier, of Bern.

In passing let me add that only four American citizens have so far been honored by being elected foreign associate members of the French Academy of Sciences: Benjamin Franklin, Simon Newcomb, Louis Agassiz, and Alexander Agassiz.

Pardon me that I was tempted by my patriotic fervor and by the presence of so many men of science to say more about my compatriots than I originally intended, and let me revert again to Professor Hassler, to whose fame I owe my presence here.

Ferdinand Rudolf Hassler, born in 1770 in the charming little town of Aarau, was the son of a highly respected and wealthy watch manufacturer. After putting him through the Swiss schools his father sent him to Bern to study under one of the most renowned mathematicians of those times, Johann Georg Tralles, a German. Tralles had been commissioned to make the first geodetic survey of Switzerland, and his pupil Hassler, at that time 21 years old, assisted him by taking independent charge of the measurement of a base line in his home Canton of Aargau, which was to be the foundation of the triangulation. Later on he went to Germany to attend lectures on astronomy, political economy, and diplomacy, and afterwards to France to complete his studies in mineralogy, chemistry, mining, and mining law. After his return to Switzerland he married Marianne Gaillard, of Murten. His fellow citizens immediately recognized his ability and conferred various offices on him; thus he was called upon to act as counsellor and state's attorney in the Canton of Aargau.

But a desire for wider fields of activity seized him when the news of the success of Swiss settlements in the United States spread throughout Switzerland.

In 1805 Hassler and his family left the Helvetic Republic, accompanied by 120 of his compatriots, who were capable and enterprising, but anxious to exchange the narrow limits of free Switzerland for the boundless possibilities of the equally free New World. Hassler emigrated, not as an adventurer, but as a scientific pioneer in the fullest sense of the word. He carried with him his splendid library of over 3,000 volumes and his collection of technical instruments, the like of which had never before crossed the ocean. In the course of time, however, overtaken by the vicissitudes of fate, he was compelled to sell his beloved books.

In Philadelphia, the seat of government at that time, he was cordially received by Albert Gallatin and introduced to President Jefferson. The President soon perceived the power in the young savant which could be utilized in the development of the governmental project for a survey of the coasts.

In 1807 Congress decided on starting the work, and in answer to a circular request 12 plans were submitted by eminent scientific men, among them Hassler's, which was adopted. Accordingly, the work was intrusted to him and its execution became the principal occupation of his life and established his high reputation. At that time Hassler was professor of mathematics at the newly created Military Academy at West Point. He held this position until 1811, when, after Congress had appropriated the necessary money for the purchase of instruments, he went to London to order and supervise their construction and delivery; but the outbreak of the war with England in 1812 caused many delays and not until 1815 could the many difficulties be overcome. Finally, in 1816, a beginning was made of the survey of the coasts. Financial reasons, however, prevented its prosecution beyond 1818, and Hassler retired to a farm at Cape Vincent, New York. He remained without Government employment for 12 years, a period abundantly productive of scientific work.

At the request of the Treasury Department he commenced in 1830 the comparison of weights and measures in use in the customhouses and the construction of standards. Two years later he again assumed the duties of Superintendent of the Coast Survey. Under his able direction the Survey rapidly expanded. One hundred engineers and 20 surveying vessels were incessantly employed on the survey, when, in 1843, at the age of 73, death put an end to his beneficent endeavors.

Notwithstanding his long life in America, Hassler always preserved an affectionate attachment for his fatherland. It is touching to learn that during the long and ceaseless journeys which he was compelled to make in his coach he always carried a Swiss music box that he might hear the Alpine tunes of his old home. He left five sons and two daughters. Several of his descendants live in the United States and some of them here in Washington. When his remains were buried in Laurel Hill Cemetery, Philadelphia, officers of the Army and Navy placed upon his coffin a parchment which says in conclusion:

> His scientific writings and the national works created by him for the United States serve not only as beautiful memorials of his active life but for the education and enlightenment of mankind.

In his memorial of Hassler, Professor Alexander said of him: "He was patient, fearless, and industrious. In his character he united everything which may be called great and good."

Gentlemen, priding ourselves with such men as ties that bind it is but natural that the social as well as the commercial relations between our Republics should be of the most agreeable kind, just as they always have been. The present stress, however, through which the world is passing has tended to unite us still more closely. Switzerland, surrounded as she is by belligerent powers, looks to the United States as her basis of supply to a much greater degree than ever before. On the other hand, in your mighty and rapidly developing Union the philanthropic activities of Switzerland, as well as her citizen army, are frequently discussed in the most friendly and sympathetic manner. Our two countries, though separated by the oceans, are to-day pursuing the same great aim and goal—peace.

May President Wilson, the exalted citizen at the head of the United States, be crowned in his sublime endeavor with lasting success.

Mr. JONES: It has been a privilege to hear this address from Doctor Ritter, and I am sure I voice the sentiments of all present in extending to him our hearty thanks.

Many of you know that the Coast and Geodetic Survey is represented in many parts of the earth. I have received to-day some telegrams from those who are deeply interested; some from our own officers at home and in distant lands and others from men who have helped build up the Coast and Geodetic Survey and are now identified with other institutions. The first one which I would like to read to you is from Professor John F. Hayford, head of the College of Engineering of Northwestern University and one of the famous geodesists in the world:

COLLEGE OF ENGINEERING, NORTHWESTERN UNIVERSITY,
Evanston, Ill., April 6, 1916.

Greetings to the friends of the Coast and Geodetic Survey assembled April 6, 1916, in celebration of the hundredth anniversary of the Survey:

I regret that I am unable to be present in person. I am with you in spirit.

I appreciated so thoroughly the privilege of being connected with the Coast and Geodetic Survey for 17 years that I can not quickly forget the Survey nor fail to rejoice in its prosperity and long life.

During its century of activity the Coast and Geodetic Survey has contributed to the safety of navigation more than it is possible to fully realize. It has contributed more, as the earliest scientific bureau, to the upbuilding of Washington science than it is possible to trace. It has put the mapping of the interior of the United States on a firm basis for all time. It has contributed liberally to progress in the branches of science which it has touched.

I congratulate, especially, those of you who are still carrying forward the flag of the Coast and Geodetic Survey to new and greater triumphs.

JOHN F. HAYFORD.
(Formerly in the Coast and Geodetic Survey, 1889–1895 and 1898–1909.)

A word of greeting from our representative in Honolulu:

HONOLULU, *April 5, 1916.*

COAST SURVEY, WASHINGTON:

Alóha nui lóa from Hawaii. (Best congratulations from Hawaii.)

MERRYMON.

I have an interesting message, not from one of our own officers, but from a representative of a sister Republic.

MEXICO CITY, *April 6, 1916.*

E. LESTER JONES, *Superintendent.*

Confirm letter sending greetings on celebration of hundredth anniversary of the creation of the Coast and Geodetic Survey, commemorating fact of far-reaching importance in the annals of human culture.

PEDRO C. SANCHEZ,
Director of Geographical and Climatological Studies of Mexico.

The work of the Coast and Geodetic Survey has been closely interlocked during many years with the Navy Department. We have been not only closely affiliated with them in protecting and safeguarding the waters, but in the early history of the Survey many of its officers were detailed from the Navy and the success of the Survey is in a measure due to their assistance. I take great pleasure in introducing to you the Secretary of the Navy.

THE COOPERATION OF THE UNITED STATES COAST AND GEODETIC SURVEY AND THE NAVY

Secretary Daniels: Mr. President, Mr. Superintendent, I wish to express my grateful appreciation to the distinguished minister from Switzerland for giving an answer to a question which we have been trying to answer in the Navy Department for more than a year. You will recall that the Sixty-second Congress authorized a mobilization of the fleets of the world to go through the Panama Canal and celebrate formally the opening of that great artery between the oceans, and when we came to send invitations to all the nations of the world we sent an invitation to the navy of Switzerland. The bright paragraphers all over America began to have fun with the Navy Department, thinking it had made a great error in honoring that Republic with an invitation to take part in a naval parade. You have the answer to-night. When Mr. Jefferson, with that vision that characterized him above all of his fellows, wished to establish in America the Coast Survey, he turned to the Republic of Switzerland and brought here the distinguished gentleman who was the first head of this Survey. And it was interesting to me, as it was to you, to learn from the distinguished minister that both these disciples of science devoted themselves so unreservedly to the public welfare that both of them had to sell their libraries.

The Navy and the Coast and Geodetic Survey are twins. I do not know to-night, speaking for the Navy, whether we are here mostly in pride at the achievements of this Survey or in envy that it is no longer domiciled in the Navy Department. For nearly two years it was of the Navy Department and for many other years distinguished naval officers had their first commands in the Coast Suivey. The Hydrographic Office, in our department, and the Survey maintain such close relationship that we do not know where one begins and the other ends; and if some night Secretary Redfield and the Superintendent were to go to sleep they might wake up the next morning to find that we had ordered the Navy and the marines to take the Coast and Geodetic Survey and bring it back into the Navy Department.

We have now come to know that no matter how great are our ships, how skilled our navigators, unless we have charts made by you gentlemen they will run upon reefs, and the dreadnaughts and the submarines will fail at the vital time.

Therefore, while we are regretful that the Coast and Geodetic Survey no longer is in the Navy, we are looking forward to an achievement by this branch of the service which will add even more reputation to it than all its achievements of the past, because we are upon the threshold of a period when the battles of the world will not be fought on land or on sea alone but in the air, and I look to you gentlemen to chart the air as you have charted the ocean, so that when the "airy navies grapple in the central blue" they will be able to miss the pockets and hit the enemy.

Mr. Jones: I would like to say just a word in response to one part of the Secretary of the Navy's address. He prophesies that some morning the Coast and Geodetic Survey might wake up to find itself taken over by the Navy. This would be quite impossible, for the Survey never sleeps.

There are several more telegrams which you would like to hear. From one of our commanders now in southern waters:

Beaufort, S. C., *April 5–6, 1916*.

The Superintendent of the U. S. Coast and Geodetic Survey:

The officers of the *Hydrographer* join me in extending congratulations to you and to the members of the Survey gathered together on this momentous occasion, the centennial of our Survey. We pledge our loyalty in aiding you in the work to which you are devoting yourself, continuing the long and honorable record of the Survey, and extending its usefulness to meet the exacting demands of these modern times. May success attend you in your efforts.

Frank G. Engle.

It is peculiarly fitting that in this centennial year we should construct on the Great Lakes the first thoroughly efficient Survey vessel. The vessel's name is the *Surveyor*. The inspector in charge, Captain Yates, has sent a very appropriate telegram.

Manitowoc, Wis., *April 6, 1916*.

The Superintendent of the U. S. Coast and Geodetic Survey:

On behalf of new ship *Surveyor*, please accept my compliments and congratulations on the centennial of the Coast Survey. If opportune, please state to my colleagues and old shipmates that the *Surveyor* will be under way from the Great Lakes to Alaska before the close of navigation, and that she will thus fittingly celebrate our centennial year by circumnavigation, as near as can be, the 10,000 miles of ocean coasts to which they, and their predecessors for a hundred years, have devoted their lives in surveying and charting for the safety of life and the promotion of commerce at sea.

Charles C. Yates.

One from our inspector at Seattle:

Seattle, Wash., *April 6, 1916*.

The Superintendent of the U. S. Coast and Geodetic Survey:

The Pacific-Northwest contingent sends greetings, with the loyal assurance that every effort will be made to continue with renewed and accelerated vigor the work that the past has proved to be so comprehensive for the safeguarding of life and the promotion of commercial prosperity.

J. F. Pratt.

From our officer in charge of the magnetic observatory at Tucson, Arizona:

Tucson, Ariz., *April 6, 1916*.

Superintendent U. S. Coast and Geodetic Survey:

The Survey is, and rightly deserves to be, congratulated on its efficiency, usefulness, and unselfishness.

F. P. Ulrich.

It is very pleasant to me to be able at this time to say a word of one for whom I have deep feeling. For three years I have been associated with him, and that association has been more than a pleasure; yea, it has been a privilege. Whenever encouragement was needed or cooperation desired he was ever ready to assist in every way he could. It affords me exceeding pleasure to present to you the Secretary of Commerce.

THE SCOPE AND NEEDS OF THE UNITED STATES COAST AND GEODETIC SURVEY

Secretary REDFIELD: Mr. President, Mr. Superintendent, ladies and gentlemen, the record of service that we close to-night is one of which any group of men may well be proud. The fine traditions of this service that survive in your hearts I know are dear to you. I know a little what they have meant to you of personal sacrifice and of struggle under adverse conditions. I know what you have done in the lonely places of the world unseen and unwatched, untold, with none to advertise. I want it known that we here know and appreciate and honor the men who carry the burden and heat of the day.

The work of surveying and engineering is not spectacular. It is not comfortable to climb a mountain peak with a pack of instruments upon your back. There is nothing that gets readily glorified in being a victim to mosquitoes in Alaska, especially when the Government says, "Mosquito nets are not a part of your normal equipment and you must pay for them yourselves." I deeply regret that Uncle Sam is so poor that he must needs throw out the dollar and a quarter that you have to pay to make life possible when you survey the western flats of the great Territory of Alaska. Some day some man will write a book on the meannesses of Uncle Sam. It will be a very striking book, that will search many hearts. You and I know perfectly well what some of those little things are. It is a sad thing that we have to be troubled by them. There are more than one kind of mosquito in the world, and sometimes when one troubles us we have to remember to our pain that there are others who will trouble us also. But of that you who have been in the field and done the work and been at sea and done the work are accustomed to reckon little. You have thought of the doing of that work with an accuracy and a care which, as you know, has brought to you the official approval of the scientific world of Germany and has led the great Australian Commonwealth to copy your methods in its own Commonwealth Survey.

There are fine traditions in this Survey, and there are curious ones. I think it is not generally known that the artist Whistler was a draftsman in the Coast Survey. He is said by his fellow draftsman, who was a son of Francis Scott Key, the author of the Star-Spangled Banner, to have made more sketches than drawings. I think Mr. Key has said that if he could have collected the sketches that Whistler threw upon the floor when he was a draftsman he would now have a fortune and a very valuable collection.

It is also an interesting fact that out of the officers of this service grew many generals of the United States Army, and with a very singular neutrality there also grew out of this same service nearly or quite as many admirals of the United States Navy.

Let me speak to you very briefly of the present and the future of the Coast and Geodetic Survey; what it is, what it has with which to work, what its task is, what it hopes to do. We were asked not so long ago, When will its work be done? The answer to that is, When the ocean currents cease to flow, when the Mississippi River stops bringing silt to the Gulf, when Rockaway Point ceases to crawl across the entrance to New York Harbor, when earthquakes cease to trouble in a part of our frontier. Not until then will the work of this Survey itself cease, for that which is surveyed must needs be resurveyed, for the bottom changes and ships grow deeper, the ocean currents flow and winds continue to blow and engineers continue to work, so that in the single harbor of New York in a single year over 280 changes were necessary in the charts.

The work is splendid in its sweep, from the Sulu Sea just north of Borneo to the cold waters of Alaska in the Pacific, and from the tropical waters around Florida to the Canadian coast in the Atlantic, and on all the continental area of the United States between, and all along the backward limits of Alaska. Few of our services cover so completely the whole round earth. You have heard, and I think will hear still more, from the officers of the service who to-night and to-day are busy on all the seas doing its wonderful work for the saving of mankind and for promoting its commerce.

There is one fundamental distinction between this service of ours and the Navy, which it is my duty to expose to-night. Your great battleship is a wonderful thing, grim and formidable, but there is one thing of which she is dreadfully afraid, about which she is frightened a large part of the time, and from which she shrinks with constant terror. That is the bottom. It happens that we have in the Department of Commerce two fleets, small ones as fleets go—the Coast and Geodetic Survey fleet and the Lighthouse fleet—whose duty it is to go where no other ships in the world dare to go, whose specialty it is to look for the bottom. We are not afraid of the bottom in the Coast and Geodetic Survey. That is what we are for. We are very familiar with the bottom of the sea. We like it. It is our special habitat. It is the place where we belong. I have always said about the Department of Commerce that it rules the heaven above, the earth beneath, and the waters under the earth; for we have one in the wireless and the other in the geodetic part of your work, and the bottom of the sea in your hydrographic work and in the Bureau of Fisheries. I think I have made good on the assertion.

They court-martial a naval officer when he finds the bottom. We do not court-martial our men when they find the bottom. That is what our men are for so that the Navy man may cast aside his fear and need no longer tremble, but may go in safety where we have been before him. A great battleship with its twenty-odd thousand tons of steel must needs follow and never lead the little *Hydrographer* and the *Bache* and their sister vessels, and so it will be, we expect, until the end of time.

There is one tradition in the Coast and Geodetic Survey about which I speak with peculiar fondness, and that is the magnificent and adequate building which houses it here in Washington. I speak of it first as a luxury, because it is of such a character that only a wealthy nation could afford to run it. Any poorer State would be sunk by the cost. But I wish to point out to you, my friends in the service, certain ethical and scientific values in that very peculiar structure which you inhabit. In the first place it has marked moral value, for it forces you to refrain from profanity all the time. In the next place it has marked spiritual value, because there is nothing more tangible in the way of value about it. In the third place, inasmuch as your work is largely that of precise leveling, the building was specially arranged with 16 levels, on 4 floors, to teach you what levels meant.

Then I have to congratulate you on your endurance of those magnificent specimens of naval architecture which you have, so many of you, commanded on so many seas and which, let us hope, are now, through the kindly wisdom of a thoughtful Congress, being relegated to the scrap heap. You ought to know, however, the great value those vessels have. This is a time when ships are busy and costly. We have sold three seagoing vessels within 15 months. We got $1,050 for one, including its engines. We got $3,050 for another, including its engines and equipment, and $3,150 for the third, a total of less than $8,000 for three seagoing steamers. And that, gentlemen, was more than their worth. I hope the day is gone—I believe it has gone, and there are good signs that it has gone—when scientific men are given most unscientific tools with which to work.

The job—you know it, I would to Heaven the people of the country knew it better—with 103,000 miles of coast to survey, and much of it yet untouched, the job in Alaska alone greater than the whole task of the United Kingdom of Great Britain and Ireland, the job in the Philippines alone greater than the whole task of France, the job on the Pacific coast of the continent of the United States and Hawaii greater than the whole task that Germany has set before it; the most tremendous and colossal task of the kind in all the world, no two nations together having anything which at all approximates it in difficulty and in extent, that is the task at which you have labored for 100 years, you and your predecessors, and it has only begun. It is begun so little that we have lost in Government vessels alone in Alaska within the last four or five years more than the total annual cost of your service.

I have two pictures. One is the splendid Coast Guard cutter *Tahoma* lying in the harbor of Unalaska safe, a fine ship, almost new; the other is the *Tahoma* a few weeks later where she lies wrecked, with the sea washing over her decks. Along there also will be found the fine lighthouse steamer *Armeria*. If you look in another bay of that same shore far enough down you will find the steamer *State of Washington* with, I presume, the bodies of the 31 people that went down on her. We have paid in Alaska twice the whole price of Alaska since we got it in wrecked vessels, not counting the lives of the people on board of them as worth anything at all. Nay, we have had very peculiar habits of surveying up there. We have found many rocks by running merchant ships upon them and have had the regular habit of naming the rocks after the ships which struck them. You may go along that coast now and pick up rock after rock bearing the names of the ships that were wrecked upon them.

We have been wasteful, thoughtless, heedless to the last degree. We believe—aye, we know—that the day has come when we are thinking more sanely of these things than we did.

None the less, my friend the Secretary of the Navy ran his battleship fleet into a safe place, he thought, in Boston Harbor, or just outside, only a few months ago and one of our new surveying parties with what we call the "wire drag," which Professor Hassler did not have, went after the fleet to see what it could find. It found near where the fine ship *Wyoming* had been lying only a few weeks before a bowlder which had 7 feet less water over it than the *Wyoming* drew. Those bowlders have a bad way of working with the bottom of a ship. There it lay. It was the grace of God and the accident of man that saved the vessel from going on it. We put a buoy on it by telegraph of a Sunday morning.

But not until that method of surveying was put in use for the first time a very few years ago was it possible to find these menaces, which come between the lines of soundings, and which until then were unknown. We in the Coast and Geodetic Survey do not regard the Washington Monument as especially tall. We found one under water in Alaska which was 100 feet higher, 654 feet in height, and which came to within 17 feet of the water's surface, just in the place to tear the bottom out of a ship, which had a good long distance to sink. It had come between lines of soundings in waters long charted.

We found five spines sticking up in the East River near Rikers Island, east of New York City and within a few hundred yards of where the Sound vessels have for years gone in apparent safety. One of them swinging too far some time would have torn its bottom out.

We know now that you can not navigate a vessel from Key West up the west coast of Florida reasonably near the shore with any certitude that a coral reef will not sink you. We have thousands of square miles of water unsurveyed yet on the coast of Florida. The task is vast. It is but begun. It must have men. Thank God it is given the men. It must have ships, and we have fewer ships now than there were in 1843, just about half as many, and some of them still not very good. Only one, I think I am correct in saying, perhaps two, were built for the service, and yet the whole ebb and flow of our commerce at sea depends for its security, as well as the movement of every naval vessel, upon the accuracy and the thoroughness and the continuity of this work.

One thing and I have done. Every land title depends to a greater or less extent upon accurate and continued knowledge of the operations of the past. Our seaboard titles depend upon a continued knowledge, actually kept, of the changes in the ocean line, which are many. As things now are, the records of every bit of our Atlantic water front, in which are involved the accuracy of every land-front title from New Brunswick south, are in paper rolls in a wooden room on wooden racks. I hope the common sense of America will not long allow that to continue.

As regards our interior work, we are the most backward in our general triangulation—I mean in its extent as compared with the work to be done—of all the great nations save only Russia. Indeed, India sets us a fine example by being ahead of us in the completeness and accuracy of geodetic surveys.

So that the future of the Coast and Geodetic Survey is one of work, gentlemen. So far as lies in our power, you are going to have the tools with which to work. You have got some new ones. I believe you have got the confidence of the Nation. I believe you deserve that confidence. I know that with the tools and with the men much more can be done even than to equal the honorable past upon which you justly look with pride. I thank you.

Mr. Jones: I have nothing to add to what the Secretary of Commerce has just said, except "amen."

I have a message from one of our officials in Alaska:

Sitka, Alaska, *April 6, 1916.*

The Superintendent of the U. S. Coast and Geodetic Survey:

Congratulations on the century's achievements with greetings to the assembly from the Sitka Magnetic Observatory.

J. W. Green.

One from an officer who has been in this service nearly half a century, born in Sweden and recently decorated by its King:

San Francisco, Cal., *April 6, 1916.*

The Superintendent of the U. S. Coast and Geodetic Survey:

Congratulations to the Survey on its centennial celebration. Proud to have served it almost one-half of that period, and pledge continued loyalty to our distinguished service.

Ferdinand Westdahl.

From our inspector in Galveston:

GALVESTON, TEX., *April 6, 1916.*

The SUPERINTENDENT OF THE COAST AND GEODETIC SURVEY:

Congratulations to all the officers and guests at the celebration of the one hundredth anniversary of the Survey. May they and it live long and prosper. Regret that I can not be with you.

J. B. BOUTELLE.

The next message is from one not now connected with the service, a retired naval captain, who has played a very important part in years gone by in carrying on to a successful conclusion the work allotted to him.

SAN FRANCISCO, CAL., *April 5, 1916.*

E. LESTER JONES,
Superintendent.

I regret exceedingly that distance alone prevents me from accepting your invitation to the banquet commemorating the one hundredth anniversary of your organization. My long service on Coast Survey detail permits me to extend sincere congratulations for eminent work performed, and my best wishes go with you for future success.

JEFFERSON F. MOSER.

From the inspector at our New York office:

NEW YORK, *April 6, 1915.*

The SUPERINTENDENT U. S. COAST AND GEODETIC SURVEY:

Impossible to be present in person, but my best wishes are with you as always.

E. F. DICKINS.

From a former member of the division of geodesy, Republic of Mexico:

TACUBAYA, D. F., *April 6, 1916.*

COAST SURVEY, *Washington, D. C.:*

To the men of the Coast and Geodetic Survey of America who for 100 years studied to learn the size and shape of the earth. With them all was construction, not destruction.

A. LEYVA.

A cablegram from our director at Manila:

MANILA, P. I., *April 6, 1915.*

COAST SURVEY, *Washington, D. C.:*

All join centennial congratulations.

F. MORSE.

A radiogram from our chief of party at Vieques, Porto Rico:

VIEQUES, P. R., *April 6, 1916.*

COAST SURVEY, *Washington, D. C.:*

Felicitations on completion of 100 years of valuable work.

H. W. PEASE.

Ladies and gentlemen, we have a gentleman with us to-night who in past years has done much for the development of the Coast and Geodetic Survey. Although some years have passed since the period of his service, his efforts and what he accomplished are felt more each day. We are honored in having with us the senior former Superintendent. I take great pleasure in introducing to you Doctor Thomas Corwin Mendenhall.

THE SUPERINTENDENTS OF THE UNITED STATES COAST AND GEODETIC SURVEY

Doctor MENDENHALL: Mr. President, Your Excellency the Minister from Switzerland, Mr. Secretary of the Navy, Mr. Secretary of Commerce, Mr. Superintendent, members of the field and office force of the United States Coast and Geodetic Survey and their friends, the honor of being one of the speakers on this memorable occasion is highly appreciated, in spite of a perfect realization of the fact that it comes to me solely because I have had the fortune, good or bad, to survive my predecessors. To live long, according to a well-known proverb, is to prove that one is not a favorite of the gods; on the other hand, to live long is to furnish fairly good evidence that one has not been found guilty of a capital crime.

During the past two days the various activities of this service have been so thoroughly discussed by competent critics that there is little room for further comment. As I am representing the men who directed these activities during the century of its existence, I choose to speak, not *for* them, but *of* them, the Superintendents of the Coast and Geodetic Survey, with some reference to their share in the development of the work.

To the Republic of Switzerland American science is enormously indebted. Thence came Agassiz, Guyot, Lesquereux, and others who stirred us into scientific activity 50 years ago, and more than a half century earlier came Ferdinand Hassler, organizer and first Superintendent of the Coast Survey. No brief sketch can do justice to Hassler's personality or to his all-powerful influence in molding the character of the new organization, the first of the so-called "Scientific bureaus" of the United States Government. Educated in the best schools of Europe, intimately acquainted with the most eminent scientific men of the Old World and with experience in the trigonometrical survey of his native country, he possessed exactly the qualifications necessary to a successful launching of the new enterprise. Not the least of these qualifications was one rather rare among men of science, though common enough in the so-called "learned professions." With intellectual power and technical skill of the highest order he combined an equally high appreciation of his own merits. It is related that when invited to organize and direct the survey of the coasts, which had been strongly recommended to Congress by Thomas Jefferson, he demanded and received a salary equal to that of the head of the department to which the new bureau was assigned. Tempora Mutantur! There is also a tradition that when the President objected, saying, "Your salary is as large as that of my Secretary of the Treasury, your superior officer," he replied, "Any President can make a Secretary of the Treasury but only God Almighty can make a Hassler."

Visiting Europe in 1811 to purchase the necessary instruments and standards of measure, the execution of his mission was protracted to the close of 1815 by the outbreak of the war of 1812, and thus a period of nearly 10 years elapsed between its authorization by act of Congress and the actual inception of the Survey.

Hassler's plan of organization, broad and thoroughly worked out, is still the fundamental directing ordinance of the Coast and Geodetic Survey. He provided for the division of its operations into three great groups, the geodetic, the topographic, and the hydrographic, and of these he considered the geodetic the most important as affecting the accuracy and final value of the results. In insisting upon a degree of precision in the execution of these operations hitherto undreamed of in this part of the world, he "set the pace" which the Survey has since maintained with such distinction and which it must continue to maintain if its future is to be worthy of its past.

Naturally a man of his temperament was likely to come into occasional conflict with Government authorities, who were quite unable to appreciate the nature and demands of such a service. The very refinement in measure and computation, which was the chief merit of the work, came near being the undoing of Hassler, as it has, indeed, of more than one of his successors. In 1842 a congressional committee made a searching and unfriendly investigation of the Survey, during which, as one of its members confessed on the floor of the House, it was found that of the subject under consideration the Superintendent knew so much and the inquisitors so little that the committee was helpless in his hands. Although the work of this committee, like that of most of its successors, was an inquisition rather than an investigation, its report was practically a complete indorsement of the principles on which the Survey had been conducted by Hassler. His death occurred in the following year, but not before a complete and comprehensive plan for the continuation and expansion of the work had been outlined by him and approved by the President.

The duty of executing this plan, of building upon the foundation laid by Hassler, fell to one who was everywhere acclaimed as the best fitted for the task.

Alexander Dallas Bache had inherited through his grandmother, the famous "Sally Bache" of the Revolutionary period, only daughter of Benjamin Franklin, not only his distinguished ancestor's tastes for scientific pursuits but also much of his tact and skill as a diplomat, a quality that contributed in no small degree to his notable success as Superintendent. After graduating from West Point Military Academy at the age of 18 years, at the head of his class, with the extremely rare record of having completed the entire course without receiving a single demerit, he had enjoyed a wide experience in public service in various capacities, besides being actively engaged in important researches in magnetism and electricity. At the age of 37 years he had already won distinction as a scientific man of originality and power, and his appointment as Hassler's successor was recommended by all of the principal scientific societies and institutions of learning in the country. His service extended over a period of almost exactly a quarter of a century, being terminated by his death in 1867. The splendid superstructure which Bache erected upon Hassler's foundation has received the highest praise from competent judges in all parts of the world. During his administration he was successful in securing the confidence of Congress, and the operations of the Survey were greatly extended. While keeping well in mind the practical results for the attainment of which the organization was created, he had a keen eye for the purely scientific by-products, of which he gathered a great harvest. The distinguished mathematician and astronomer, Professor Benjamin Peirce, on assuming office as his successor said of the Coast Survey at the end of its first half century: "What it is, Bache has made it. It will never cease to be the admiration of the scientific world. It is only necessary conscientiously and faithfully to follow in his footsteps, imitate his example, and develop his plans."

During the later years of Bache's administration Professor Peirce had directed the longitude operations of the Survey, acting also as a sort of general scientific adviser, and naturally his policy after becoming Superintendent was essentially that of his predecessor. Many of the larger operations of the Coast Survey had been suspended during the Civil War, in which both the Superintendent and his assistants had played an important part. The execution of the primary triangulation on both the east and west coasts was resumed by Peirce and an exploration and survey of the newly acquired Territory of Alaska was begun. The most important act of his administration was the development of a plan for two gigantic chains of triangles extending across the continent, thus covering the whole country by a trigonometrical survey and joining the systems of the Atlantic and Pacific coasts. This scheme received the approval of Congress and was in many respects the most remarkable work of its kind ever undertaken by any Government.

Peirce had continued to hold his professorship in Harvard University and also kept up his many other activities, as a writer of textbooks, a frequent contributor to scientific journals, etc., and at the age of 65 years, doubtless finding his burden too heavy, he resigned the superintendence of the Survey in 1874, after a service of seven years, but he continued to act for a time as "consulting geometer." As a genius in mathematics and astronomy he is easily a star of first magnitude in the Coast Survey galaxy.

Peirce's successor was Carlile Pollock Patterson, naval officer and son of a naval officer. Previous to his appointment as Superintendent he had served for more than a dozen years as hydrographic inspector, an appointment usually held by a naval officer, active or retired. The general plans of the Survey as perfected by his predecessors were adhered to by Patterson, whose term as Superintendent covered a period of seven years, ending with his death in 1881.

His successor, Julius Erasmus Hilgard, was brought at the age of 10 years from his birthplace in Germany by his father, a highly educated and successful lawyer and jurist in his own country, who settled on a farm in Illinois near the city of St. Louis. Educated by his father, young Hilgard at the age of 18 years went to Philadelphia to study to be a civil engineer. There he soon attracted the attention of Professor Bache, who invited him to become one of his assistants in the Coast Survey. In 1845 he joined the corps, his connection with it terminating on his resignation in 1885 after 40 years of service. His industry and rare talents brought rapid promotion, and in 1862 he became assistant in charge of the office at Washington, a position then next in importance and responsibility to that of Superintendent. In this capacity he served for 19 years, until his appointment as Superintendent in 1881. In the meantime his reputation had become international. He was one of the most influential members of the International Metric Commission that met in Paris in 1872; was made a member of its permanent committee, and on the organization of the International Bureau of Weights and Measures, with headquarters at Paris, he was offered the directorship. This honor he declined. By training, ability, and experience Hilgard was more completely fitted for the headship of the Coast and Geodetic Survey than any other person who has ever served in that capacity, and it was unquestionably the goal which he had hoped to reach. Recommended for the appointment, as Bache had been 40 years earlier, by scientific men, learned societies, colleges, and universities, he began his administration under the most favorable conditions. During earlier years his work justified the confidence reposed in him, but in the meantime, unknown to his friends and perhaps unsuspected by himself, he had become the victim of an insidious disease which weakened the power of both his will and his intellect. Undoubtedly advantage was taken of this fact by others, and an investigation of the affairs of the Survey brought to light certain irregularities in its business management which, although there had been no malversation of public funds for personal advantage, was nevertheless so inconsistent with proper bureau administration that it necessitated a change in the superintendency, and a long and brilliant career ended in almost a tragedy.

The investigation referred to was made by a commission of three employees of the Treasury Department, with Frank Manly Thorn, chief clerk of Internal Revenue, as chairman. Mr. Thorn was placed temporarily in charge of the Survey in 1885 and afterwards, by appointment of the President, he continued to act as Superintendent until the close of the first Cleveland administration. The unprejudiced historian can not fail to accord to Mr. Thorn great credit for the way in which he managed the affairs of the Survey during this trying period. Inspired by a prospect of participating in the spoils of office, a number of witnesses had volunteered testimony that was either grossly misleading or absolutely false, and this had been incorporated in the report of the commission of which he was chairman, along with a severe arraignment of the business methods of the Survey and of the integrity of several of its principal officers. A man of sterling integrity, he had the courage to revise the report of his commission by innumerable additions and annotations, practically vindicating the men against whom charges had been made, most of which were merely technical. During the nearly four years of his administration he learned much about the methods and requirements of such a service as the Coast and Geodetic Survey of which in the beginning he had been totally ignorant.

In spite of the unwholesome conditions existing in the beginning of Thorn's administration the operations of the Survey were continued without serious interruption and much important work was accomplished.

A much more regrettable state of affairs prevailed during a considerable period of the administration of General William Ward Duffield, who served as Superintendent for about three years following his appointment in the autumn of 1894. Not only was the influence of the spoilsman again paramount, but for some unexplainable reason a number of men were dismissed from the force whose places could not be filled from any source whatever. Men of long and faithful service whose reputation was international were lost to the Survey at that time, though a few were afterwards reappointed. It is charitable to assume that the Superintendent, who was by profession a civil engineer with a record of good service in the Civil War, had passed the years of discretion before receiving his appointment. That the partial paralysis by which the service was then afflicted did not become complete was due entirely to an unwavering loyalty to its best traditions on the part of those who remained.

The historian would gladly pass over these unpleasant episodes, but a due regard for the good name and fame of many individuals involved demands brief reference to them.

I come now to the living whose connection with the service is quite within the memory of most of those interested, and of whose work little need be said. There are times when brevity is not only the soul of wit but also the essence of discretion.

Upon Henry Smith Pritchett, astronomer and son of an astronomer, fell the task of making a complete reorganization of the hydrographic operations of the Survey. From the earliest days these operations had been carried on almost entirely by naval officers detailed for that purpose, but during the War with Spain such details became impossible. The difficult problem thus presented was solved with marked success by Pritchett, and this reorganization, though but one of many notable things accomplished during his comparatively short term, from 1897 to 1900, must be regarded, I think, as the most important act of his adminstration.

The appointment of Otto Hilgard Tittmann as successor to Pritchett on the resignation of the latter was an event predetermined by his long connection with the service, which began in 1867, when he was 17 years old, and continued without interruption for almost a half century, to his resignation in 1915. Inheriting through his mother the scientific tastes and special talents of the Hilgards, with successful experience in nearly every one of the various operations of the Survey, including many years as assistant in charge of the office and Assistant Superintendent, his remarkable career ended with the longest term as Superintendent since the time of Hassler and Bache. Under his direction the Survey advanced with great strides and so many important things were accomplished that it is difficult to select even one for mention in this brief review, but among those of first rank will surely be found his personal and official services in representing the United States on numerous international commissions and boundary tribunals.

I am tempted to overstep the bounds laid down for me, to pay my tribute to the ability, faithfulness, and loyalty with which the assistants of the Superintendent have almost invariably supported him in the discharge of difficult and often disagreeable duties. And I use the term "assistant" as including not only those employed in the field but also the office force, the computers, draftsmen, engravers, printers, mechanicians, clerks, etc., through whose hands all of the work of the field officers must pass before it becomes useful to the public. Without this support the ablest chief could accomplish little or nothing. I would like especially to speak of a few of the veterans of my own time who have passed away; of Whiting, who, beginning with Hassler, had served for more than a half century and under every Superintendent up to the day of his death; of Davidson, the oracle of the Pacific coast, whose service was nearly as long; of Schott, the severe but just judge at the head of the computing division; of Mosman, Fairfield, Eimbeck, Ogden, Granger, Preston, Mitchell, Smith, Rodgers, and others; it is a long roll but it is a roll of honor in the annals of the Survey. To them and to many others, happily still living, I owe a debt of gratitude for their loyal cooperation and support.

I should like very much to speak more than briefly of the many famous men who have been at various times closely associated with the Survey as a part of its working force, with some of whom it was the beginning of a brilliant career; of the great artists, Whistler and Harrison; of the great scholars, Aggasiz, Ferrell, the two Peirces, and others; of Blake, the inventor, and of many others who rose to distinction in one way or another, but in this I must not indulge.

I desire also to testify to the great importance to the Service of the cooperation of the Army and Navy, especially in the detail of officers from the Corps of Engineers of the Army in the early days and from the Navy during many years for special duty under the Superintendent, to whom they were, almost without exception, unselfishly loyal.

If I could summon their spirits from the "vasty deep" I am sure those of the former Superintendents who are dead would join with those who are living in congratulating their successor, who has recently been charged with the responsibility of directing its operations, on the thoroughly trained and competent corps of assistants who will aid him in carrying the Coast and Geodetic Survey into its second century. But perhaps even more important than these will be the traditions of a hundred years, which he will not lightly put aside.

The Survey has often been the object of adverse criticism, based on ignorance of the character of its work, because of the slowness of some of its operations. It is to its everlasting credit that as far as known no one has ever found fault with it for not keeping its work up to the highest standard attainable at the time.

Not "How much" but "How well" has been its criterion.

It is only by persistently adhering to standards of quality rather than quantity that it will continue to be as it was in the middle, and still is at the end, of its first century, "The admiration of the scientific world."

Mr. Jones: Realizing to the fullest extent the many cares already oppressing our next speaker, I yet had the temerity to ask him to be with us to-night and speak. He very kindly granted my request, only asking that he speak last, so that in case anybody "started anything" he might have his opportunity; he is the best judge of whether anything has been "started."

The Coast Survey had its beginning under President Jefferson, of Virginia, and it is a very happy coincidence that we round out the century under another President from the State of Virginia. I feel it the greatest honor to introduce to you the President of the United States.

ADDRESS BY THE PRESIDENT OF THE UNITED STATES

The President: Mr. Minister, Mr. Superintendent, ladies, and gentlemen, I had another reason for asking to come last. I remember reading with appreciation in the preface of a volume of essays written by a very witty English writer a passage to this effect, "The pleasure with which a man reads his own books is largely dependent upon how much of them has been written by somebody else;" and I have found that my enjoyment of making speeches after dinner is almost directly in proportion to the amount of inspiration that I can derive from others.

It was manifestly impossible for me to make such preparation for addressing you to-night as I should have wished to make in order to show my very great respect and admiration for this service of the Government. I can only say that I have come here for the purpose of expressing that admiration. I have been very much interested in the speeches that I have heard to-night, not only because of what they contained but also because of many of the implications which were to be drawn from them. I was very much interested indeed in the excellent address of the representative of the free and admirable Republic of Switzerland. He reminded us of what we must constantly remember, our very great intellectual debt to Switzerland, as well as to the many other countries from which we draw so much of our vitality and so much of the scientific work which has been accomplished in America.

As he was speaking, I was reminded (if there are Pennsylvanians present, I hope they will forgive this story) of a toast mischievously offered at a banquet in Philadelphia by a gentleman who was not himself a Pennsylvanian. He said he proposed the memory of the three most distinguished Pennsylvanians—Benjamin Franklin, of Massachusetts; James Wilson, of Scotland; and Albert Gallatin, of Switzerland. I dare say that in many American communities similar toasts could very truly and with historical truth be offered. And I myself had the privilege of sitting under one of the distinguised Swiss scholars to whom reference was made, Doctor Arnold Guyot, under whom I pretended to study geology. Doctor Guyot was not responsible for its not being carried beyond the stage of pretense.

I feel myself in a certain sense in familiar company to-night because a very great part of my life has been spent in association with men of science. I have often wished, particularly since I entered public life, that there was some moral process parallel to the process of triangulation, so that the whereabouts, intellectually and spiritually, of some persons could be discovered with more particularity. Yet as I listened to the Secretary of Commerce, I suspected that he was priding himself upon the discovery of a process by which he had discovered the whereabouts of a great many committees of Congress and a great many other persons connected with the process of appropriating public moneys. I have a certain sympathy with those committees of Congress which in investigating the Coast and Geodetic Survey have found that the Superintendent had the great advantage of knowing all about the service and they the great disadvantage of knowing nothing about it, because, as I have said, I have spent a great part of my life in association with men of science and, never having been a man of science, I have at least learned the discretion of keeping my opinion on scientific subjects to myself.

I have had association particularly with the very exact and singularly well-informed brother of a distinguished gentlemen present. General Scott has a brother who is a member of the faculty of Princeton University, and Professor William B. Scott is one of the most provoking men I have ever known. He not only asserts opinions and delivers himself of information upon almost every subject, but the provoking thing about him is he generally knows what he is talking about. A good talker who volunteers opinions on all subjects ought to be expected in fairness to his fellow men to make a certain large and generous portion of mistakes, because you can at least catch him napping, but Professor Scott is one of those men who successfully—I have sometimes told him I suspected adroitly—avoided the pitfalls of eminent conversationalists like himself; but association with such men has taught me a very great degree of discretion and, therefore, I am not going to express any opinion whatever about the work of the Coast and Geodetic Survey; but I am going to give myself the privilege, for it is a real privilege, of saying this: This is one of the few branches of the public service in which the motives of those who are engaged can not be questioned. There is something very intensely appealing to the imagination in the intellectual ardor which men bestow upon scientific inquiry. No social advantage can be gained by it. No pecuniary advantage can be gained by it. In most cases no personal distinction can be gained by it. It is one of the few pursuits in life which gets all its momentum from pure intellectual ardor, from a love of finding out what the truth is, regardless of all human circumstances—as if the mind wished to put itself into intimate communication with the mind of the Almighty itself. There is something in scientific inquiry which is eminently spiritual in its nature. It is the spirit of man wishing to square himself accurately with his environment not only, but also wishing to get at the intimate interpretations of his relationship to his environment; and when you think of what the Coast and Geodetic Survey has been attempting to do—to make a sort of profile picture, a sort of profile sketch, of the life of a nation, so far as that life is physically sustained—you can see that what we have been doing has been, so to say, to test and outline the whole underpinning of a great civilization, and just as the finding of all the outlines of the earth's surface that underlie the sea is a process of making the pathways for the great intercourse which has bound nations together, so the work that we do upon the continent itself is the work of interpreting and outlining the conditions which surround the life of a great nation.

I can illustrate it in this way, the way in which it appeals to my imagination: I have always maintained that it was a great mistake to begin a history of the United States intended for beginners by putting at the front of the book a topographical map of this continent, or at any rate of that portion of it which is occupied by the United States, because if you begin with that you seem to begin to deal with children when you deal with the first settlers. They knew nothing about it. They expected to find the Pacific over the slope of the Alleghenies. They expected to find some Eldorado at the sources of the first great river whose mouth they entered upon the coast. They went groping for the outlines of the continent like blind men feeling their way through a jungle. They were as big men as we, as intelligent; they had as full a grasp upon the knowledge of their time as we have upon the knowledge of ours; but set the youngster in the school to watch these men groping and he will get the impression that they were children and pigmies. That is not the way to begin the history of the United States. You will understand it only if you comprehend how little of what the work of this department of the Government, for example, has since disclosed was known to those then engaged in this great romantic enterprise of peopling a new continent and building up a new civilization in a new world.

So that you have the picture of a service like this lifting the curtain that before that time rested upon all the great spaces of nature. You remember how in the early history of Virginia a little company of gentlemen moved by a sort of scientific curiosity, and yet moved by a spirit of adventure still more, penetrated no farther than to some of the unknown fastnesses of the Allegheny Mountains and were thereafter known as the Knights of the Golden Horseshoe—given a sort of knighthood of adventure because they went a little way upon the same quest upon which you gentlemen have gone a great way.

So when I stand in the presence of scientific men I seem to stand in the presence of those who are given the privilege, the singular privilege, the almost contradictory privilege, of following a vision of the mind with open, physical eyes; making real the things that have been conjectural; making substantial the things that have been intangible.

And as the Secretary of Commerce has said, there is a great human side to the things that you are doing. You are making it safe to bind the world together with those great shuttles that we call ships that move in and out and weave the fabric of international intercourse. You are providing the machinery by which the web of humanity is woven. It is only by these imaginative conceptions, it is only by visions of the mind, that we are inspired. If we thought about each other too much, our little jealousies, our rivalries, our smallnesses, our weaknesses, there would be no courage left in our hearts.

Sometimes when the day is done and the consciousness of the sordid struggle is upon you, you go to bed wondering if the sun will seem bright in the morning, the day worth while, but you have only to sweep these temporary things away and to look back and see mankind working its way, though never so slowly, up the slow steps which it has climbed to know itself and to know nature and nature's God, and to know the destiny of mankind, to have all these little things seem like the mere mists that creep along the ground, and have all the courage come back to you by lifting your eyes to those blue heavens where rests the serenity of thought.

Mr. Jones: In bringing this notable occasion to a close I voice the heartfelt thanks of the members of the United States Coast and Geodetic Survey to the President, to the Minister of Switzerland, to the ladies and the gentlemen, who have helped to make these ceremonies such a success. I hope the next century will be as fruitful as the past. I thank you all, and good night.

LIST OF THOSE ATTENDING THE BANQUET ON APRIL 6, 1916, AT THE NEW WILLARD HOTEL

A.

Abbot, Charles Greeley.
Adams, Franklin Lancelot.
Adams, John W.
Adamson, Representative William C.
Albert, Charles S.
Alford, J. Warren.
Allen, Harlan Coffeen.
Avers, Henry Godfrey.

B.

Bache, Rène.
Bacon, Harlow.
Baker, Charles Whiting.
Baldwin, Albert LeSuer.
Barnard, Edward Chester.
Barnette, Dudley Portieuz, jr.
Bauer, Louis Agricola.
Baylor, James Bowen.
Bell, Alexander Graham.
Benedict, James Everard.
Bennett, Ira E.
Berman, Jacob.
Berman, Louis.
Berryman, Clifford Kennedy.
Bertholf, Captain E. P. (U. S. C. G.)
Bien, Morris.
Blanchard, Clarence J.
Borland, Representative William P.
Bower, Ward T.
Bowie, William.
Braid, Andrew.
Brand, Edward A.
Brigham, William E.
Brooks, Alfred Hulse.
Brooks, Daniel Hazard Lyman.
Brown, Owsley.
Burger, William Henry.
Buttenheim, Arthur W.

C.

Capstick, Representative John H.
Carlin, Representative Charles Creighton.
Castles, Percy Bennett.
Chapman, Robert H.
Childs, Samuel S.
Chilton, William Brent.
Church, Earl Frank.
Clark, Austin H.
Clarke, Frank Wigglesworth.
Clarke, Herbert C. O.
Colonna, Benjamin Azariah.
Conway, John Sebastian.

D.

Dall, William Healey.
Davis, Arthur Powell.
Davis, Frank F.
Davis, George R.
Day, Arthur Louis.
Deetz, Charles Henry.
Derickson, Richard Barnett.
Donlon, Alphonsus John.
Dorsey, Noah Ernest.
Douglas, Edward M.
Dovale, Arthur.
Duvall, Charles Raymond.

E.

Edes, William C.
Eichelberger, Professor William S.
Ela, Arthur John.
Ellis, Edmund Percy.
Ennis, Carroll Christopher.
Ewing, Thomas.

F.

Fairbank, Herbert S.
Fairfield, Walter Browne.
Faris, Robert Lee.
Fischer, Louis Albert.
Fitzgerald, Representative John Joseph.
Flemer, John Adolph.
Fleming, John Adam.
Flower, George Lewis.
Ford, Chester Arthur.
Forney, Stehman.
French, Owen Bert.

G.

Gamble, Henry Stanley.
Gannett, Samuel S.
Garner, Clem Leinster.
Gerdine, Thomas G.
Giacomini, Alfred Lewis.
Gilbert, John Jacob.
Gillett, James Norris.
Goldbeck, Albert T.
Gore, James Howard.
Graves, Henry Solon.

44282°—16——10

Graves, Herbert Cornelius.
Grayson, Cary T. (Passed Assistant Surgeon, U. S. N.).
Gregory, Henderson B.
Griffin, James Madison.
Grosvenor, Gilbert Hovey.
Guerin, W. C.

H.

Hall, Professor Asaph.
Harper, Robert N.
Harsch, Erwin.
Hastings, Clifford.
Hawley, Jean Hodgkins.
Hazard, Daniel Lyman.
Hazard, Peyton Randolph.
Heck, Nicholas Hunter.
Henderson, John R.
Henry, Nicholas Goldsborough.
Herron, W. J.
Hildreth, David Merrill.
Hill, Jesse.
Hodgkins, Howard Lincoln.
Holmes, William Henry.
Hoogewerff, Captain J. A. (U. S. N.).
Hoover, W. M.
Howard, Leland Ossian.
Howe, Charles Sumner.
Hoyt, John C.
Humphreys, William Jackson.

J.

Jacoway, Representative Henderson M.
Jervis, R. L.
Johannes, George.
Johnson, Douglas Wilson.
Johnson, Frank M.
Johnson, William Evans.
Johnston, Ralph Lowe.

K.

Kahn, Representative Julius.
Kane, Lieutenant Colonel A. J. Gordon (U. S. A., retired).
Keen, Doctor William Williams.
King, Harold Davis.
King, William Fletcher.
Kutz, Lieutenant Colonel Charles W. (U. S. A.).

L.

La Gorce, John Oliver.
Lambe, B. H.
Latham, Ector Brooks.
Lauchheimer, Colonel C. H. (U. S. M. C.).
Leland, Ora Miner.
Littell, Frank Bowers.
Littlehales, George Washington.
Luce, Gardiner.
Luce, Robert Francis.
Luellan, T. W.

M.

McArthur, Representative Clifton N.
McClellan, David P.
McCoy, Justice Walter Irving.
McGrath, John Edward.
McGuire, James William.
Mackenzie, William.
Mann, Representative James R.
Manning, Van. H.
Martin, Admiral J. A. (Argentine Navy).
Martin, Edward Richards.
Marvin, Charles Frederick.
Marvin, George.
Mellett, Lowell.
Mendenhall, Thomas Corwin.
Mendenhall, Walter Curran.
Merrill, George Perkins.
Miller, Representative Clarence B.
Minister of Switzerland.
Moffatt, Edgar V.
Mondell, Representative Frank W.
Moore, Henry Frank.
Moore, Representative J. Hampton.
Moorefield, Charles H.
Morrison, Lee.
Mourhess, Charles Albert.
Murphy, Joseph.

N.

Nevin, John Edwin.

O.

Olsen, Harry E.
Owen, Frederick D.

P.

Pagenhart, Edwin Herbert.
Parker, William Edward.
Parsons, Francis H.
Patten, Henry B.
Patterson, John Fulton.
Patton, Raymond Stanton.
Paullin, Charles Oscar.
Peabody, William Frederick.
Peary, Rear Admiral Robert Edwin (U. S. N., retired).
Perkinson, Ernest V.
Peters, William John.

Phelan, John Joseph.
Poindexter, Senator Miles.
Poor, Charles Lane.
Potter, Leon Archie.
Powell, John Dalrymple.
Pratt, Edward Irving.
President of the United States.
Purves, Thomas B.
Putnam, George Rockwell.

R.

Rathbun, Richard.
Raynor, Leroy Preston.
Reeder, C. Howard.
Reynolds, J. J.
Reynolds, Walter Ford.
Riggs, Thomas, jr.
Ritter, Homer Peter.
Robinson, Senator Joseph T.
Roosevelt, Franklin Delano.
Rose, Joseph Ferdinand.
Ross, Raymond Lawrence.

S.

Saegmuller, George N.
Sanger, William.
Schroeder, Rear Admiral Seaton (U.S.N., retired).
Schureman, Paul.
Scott, Major General H. L.
Secretary of Commerce.
Secretary of the Navy.
Sherley, Representative Swagar.
Shoemaker, Louis P.
Shore, Francis M.
Siems, Frederick Bernhard Theodore.
Sinclair, Cephas Hempstone.
Smallwood, John B.
Smith, Frank.
Smith, George Otis.
Smith, George Williamson.
Smith, Glen S.
Smith, Hugh McCormick.
Smith, U. Grant.
Snowden, Llewellyn M.
Snyder, Edgar C.
Steinberg, Max.
Stellwagen, Edward J.
Stidham, Harrison.
Stratton, Samuel Wesley.
Strong, H. C.
Superintendent, Coast and Geodetic Survey.
Sutton, Frank.
Swann, William Francis Gray.
Swem, Charles L.

T.

Taliaferro, Thomas H.
Tallman, Clay.
Thomas, Joseph B.
Thurman, Albert Lee.
Tittmann, Charles Trowbridge.
Tittmann, Otto Hilgard.
Torrey, John Day.
Towner, Representative Horace Mann.
Tumulty, Joseph P.

U.

Ulrich, Edward Oscar.

V.

Van Orstrand, Charles Edward.
Van Wagenen, James Herbert.
Vaughn, T. Wayland.

W.

Wainwright, Dallas Bache.
Wainwright, Rear Admiral Richard (U. S. N., retired).
Walcott, Charles Doolittle.
Walker, Albert M.
Wallis, William Fisher.
Warren, Frank M.
Wasserbach, Theodore.
Welker, Philip Albert.
Wendt, Edwin Frederick.
White, David.
White, William H.
Whitman, William Ross.
Widmer, Jules Adolph.
Wines, Marshall W.
Winslow, Carlile Patterson.
Winslow, Representative Samuel E.
Winston, George Otis.
Winston, Isaac.
Woodis, Fred Albert.
Woods, Elliott.
Wurdemann, Frank Gustave.
Wyvill, Edward Hale.

Y.

Young, Frederick A.

Z.

Zook, Morris A.

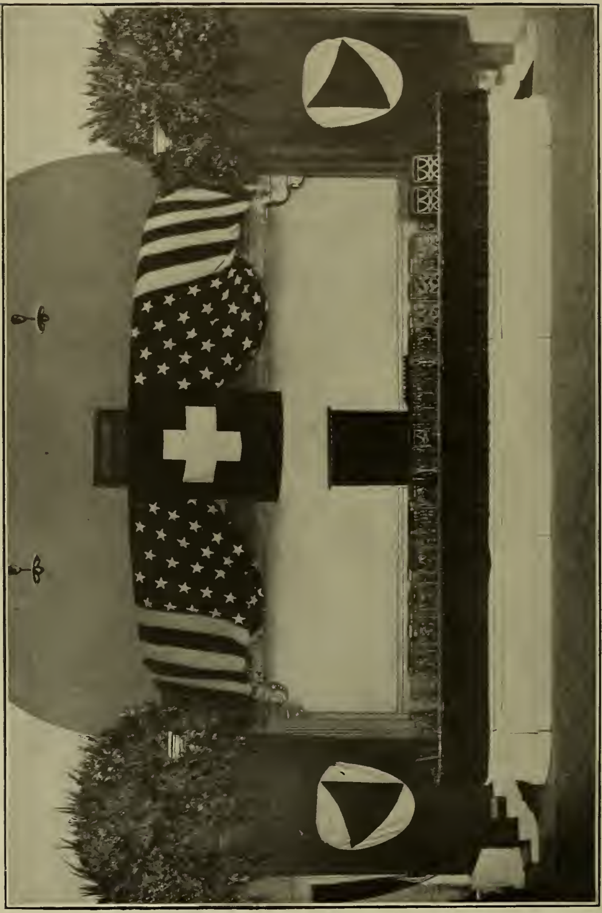

FIG. 16.—LADIES BALCONY CENTENNIAL BANQUET, APRIL 6, 1916, NEW WILLARD HOTEL

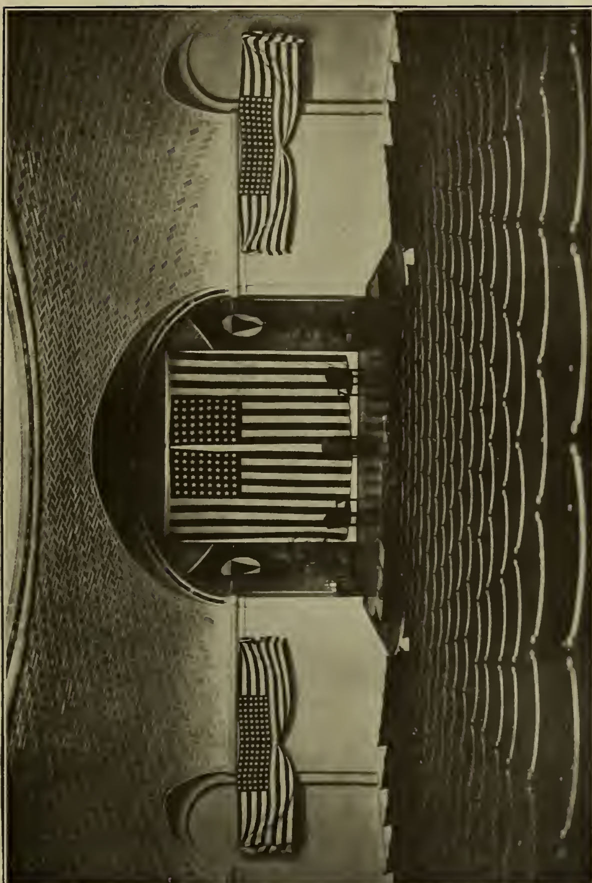

FIG. 17.—AUDITORIUM OF THE NEW NATIONAL MUSEUM, APRIL 5 AND 6, 1916

FIG. 18.—FOYER OF THE NEW NATIONAL MUSEUM, SHOWING COAST AND GEODETIC SURVEY EXHIBIT, APRIL 5 TO APRIL 9, 1916

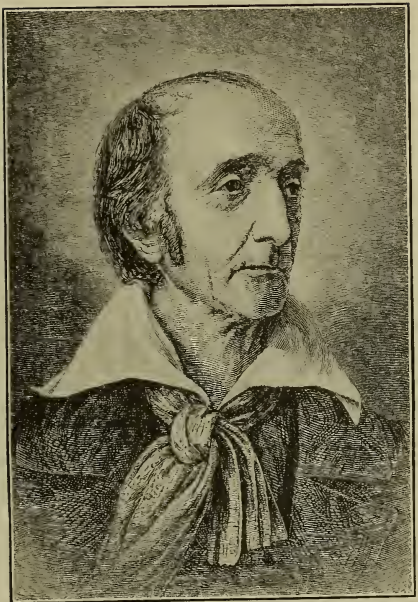

FIG. 19.—FERDINAND RUDOLPH HASSLER, SUPERINTENDENT OF THE COAST SURVEY, JUNE 18, 1816, TO APRIL 29, 1818, AND AUGUST 9, 1832, TO NOVEMBER 20, 1843

FIG. 20.—ALEXANDER DALLAS BACHE, SUPERINTENDENT OF THE COAST SURVEY, DECEMBER 12, 1843, TO FEBRUARY 17, 1867

FIG. 21.—BENJAMIN PEIRCE, SUPERINTENDENT OF THE COAST SURVEY, FEBRUARY 26, 1867, TO FEBRUARY 16, 1874

FIG. 22.—CARLILE POLLOCK PATTERSON, SUPERINTENDENT OF THE COAST AND GEODETIC SURVEY, FEBRUARY 17, 1874, TO AUGUST 15, 1881

FIG. 23.—JULIUS ERASMUS HILGARD, SUPERINTENDENT OF THE COAST AND GEODETIC SURVEY, DECEMBER 22, 1881, TO JULY 23, 1885

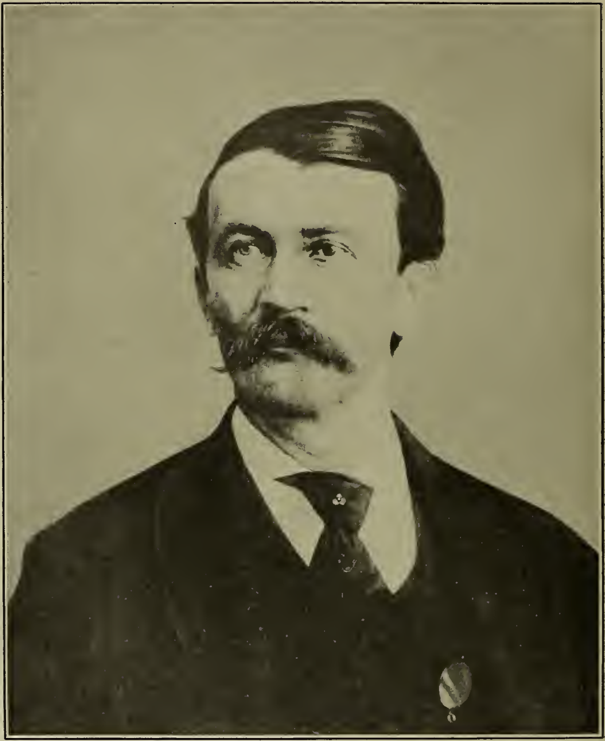

FIG. 24.—FRANK MANLY THORN, SUPERINTENDENT OF THE COAST AND GEODETIC SURVEY, SEPTEMBER 1, 1885, TO JUNE 30, 1889

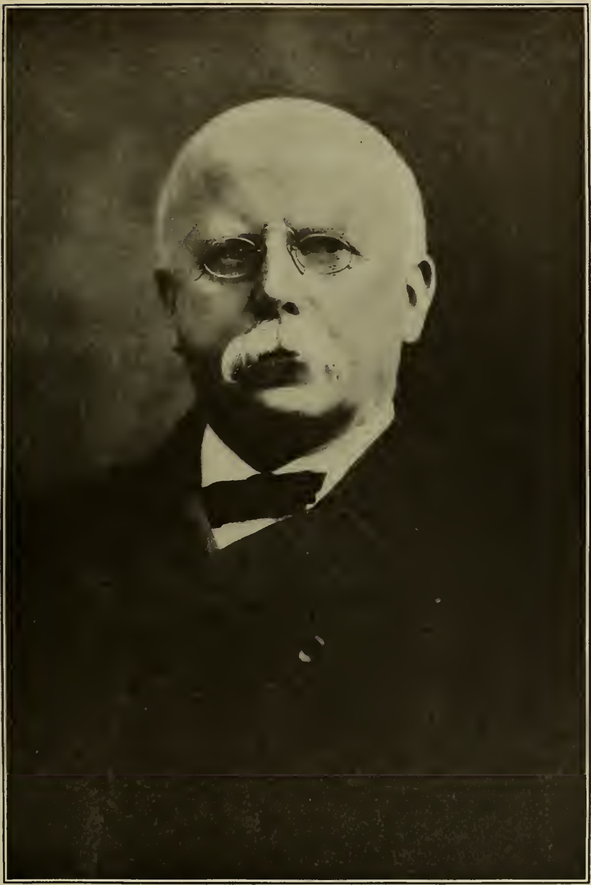

FIG. 25.—THOMAS CORWIN MENDENHALL, SUPERINTENDENT OF THE COAST AND GEODETIC SURVEY, JULY 9, 1889, TO SEPTEMBER 20, 1894

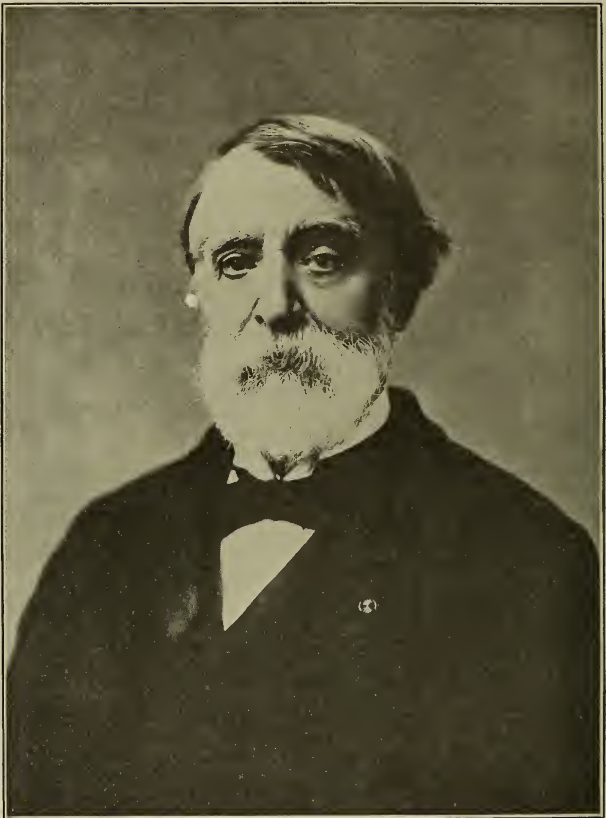

FIG. 26.—WILLIAM WARD DUFFIELD, SUPERINTENDENT OF THE COAST AND GEODETIC SURVEY, DECEMBER 11, 1894, TO NOVEMBER 30, 1897

FIG. 27.—HENRY SMITH PRITCHETT, SUPERINTENDENT OF THE COAST AND GEODETIC SURVEY, DECEMBER 1, 1897, TO NOVEMBER 30, 1900

FIG. 28.—OTTO HILGARD TITTMANN, SUPERINTENDENT OF THE COAST AND GEODETIC SURVEY, DECEMBER 1, 1900, TO APRIL 14, 1915

FIG. 29.—ERNEST LESTER JONES, SUPERINTENDENT OF THE COAST AND GEODETIC SURVEY, APRIL 15, 1915

MISCELLANEOUS

CONGRATULATORY LETTERS FROM FOREIGN INSTITUTIONS

The following are translations of letters received by the Superintendent:

MADRID, SPAIN, *April 12, 1916.*

The Secretary of the Royal Academy of Exact, Physical, and Natural Sciences presents his regards to the Superintendent of the Coast and Geodetic Survey of the United States of North America, together with his most cordial congratulations on the celebration of the centenary of the aforesaid institution, at the same time thanking him for the invitation.

Don Francesco de P. Arrillaga takes the opportunity to again express to the Superintendent his most respectful consideration.

PARIS, FRANCE, *April 12, 1916.*

The Inspector General of Mines, Member of the Institute, Director of the Bureau of Leveling of France, has the honor to thank the Superintendent of the Coast and Geodetic Survey for the very kind invitation, which he received only to-day, for the commemorative banquet, given the 6th of April last, on the occasion of the centenary of that great service. He regrets very much indeed that neither the distance nor the time has permitted him to be present and to express publicly at Washington the high esteem in which is held in France the splendid work of the largest and oldest institution in the New World dedicated to geodesy and hydrography.

To his regrets, he adds, for the Superintendent and his colleagues, the assurance of his most respectful fraternal sentiments.

CH. LALLEMAND.

GENEVA, SWITZERLAND, *May 6, 1916.*

SUPERINTENDENT OF U. S. COAST AND GEODETIC SURVEY,
Washington, D. C.

ESTEEMED COLLEAGUE: Your kind invitation to be present at the banquet in commemoration of the hundredth anniversary of the organization of the Coast and Geodetic Survey of the United States of America reached me a few days ago. In the present circumstances it would have been very difficult for a European to take part, but I am glad of this opportunity to extend to you, in the name of my country, which I have the honor to represent in the International Geodetic Association, our best wishes for the second century of activity of your service.

The people of Switzerland will be happy to know that among the orators heard on April 6, next to the Chief Executive, was the Swiss minister at Washington. It is an honor for our small and old Republic to have been thus called on to participate in the commemoration of a centenary which honors the work and fruitful activity of an official scientific service organized in its great sister Republic on the other side of the Atlantic.

I have not yet, esteemed colleague, the pleasure of knowing you personally, but I am sure that the excellent relations that I had established with your predecessor, Mr. Tittmann, will continue with you.

Please accept the expression of my distinguished consideration.

RAOUL GAUTIER.

MADRID, SPAIN, *April 11, 1916.*

The SUPERINTENDENT OF THE U. S. COAST AND GEODETIC SURVEY.

SIR: I have just received your kind invitation to the banquet which took place on the 6th of April in commemoration of the first centenary of the organization of the United States Coast and Geodetic Survey, and I desire to express to you my most sincere thanks for your courtesy.

Will you accept, sir, the expression of my deepest respect.

EDUARDO MIER,
President of the Council of the Geographic Service.

LEYDEN, *April 22, 1916.*

DEAR SIR: I received only to-day your kind invitation to attend the banquet, held April 6 of this year, in commemoration of the one hundredth anniversary of the United States Coast and Geodetic Survey.

I have the pleasure to express my sincere thanks for the honor you have done to me by that invitation, and my best congratulations. But I may be allowed to express at the same time my great admiration for what the United States Coast and Geodetic Survey has done during the past period, not only on behalf of the United States, but in behalf of science in general.

In different parts of geodesy it was the United States Coast and Geodetic Survey, which has introduced new methods and made new researches for obtaining new and better results, and has given the example, both for observations and for theoretical work, which has been followed in other countries and has furthered in a high degree our knowledge of the form, the constitution, and the motions of the earth.

From all that has been done till now, I am convinced that my sincere wish will be realized, that in the new century it has entered the United States Coast and Geodetic Survey will continue to bring for science new interesting results.

I have the honor to be, sir,

Yours, sincerely, H. G. VAN DE SANDE BAKHUYZEN.

COAST AND GEODETIC SURVEY EXHIBITS IN NEW NATIONAL MUSEUM, APRIL 5 TO APRIL 9, 1916

ASTRONOMICAL TRANSIT NO. 20. Made by Bamberg; most recent type, 1914. (See illustrations Nos. 1 and 2, Special Publication No. 35.)

ASTRONOMICAL TRANSIT NO. 19. Employed in principal longitude determinations, 1888–1913; designed and constructed in C. & G. S. Office. (See illustration No. 1, Special Publication, No. 14.)

PORTABLE ASTRONOMICAL TRANSIT NO. 3. Made by Troughton & Simms, 1847. (See figure 30.)

CHRONOGRAPH. Fuess type, 1914. (See illustration No. 3, Special Publication No. 35.)

CHRONOGRAPH NO. 6. Bond spring governor.

HIPP CHRONOGRAPH NO. 3753.

CHRONOGRAPH SHEET AND SCALE. (See illustration No. 7, Special Publication No. 14.)

CHRONOGRAPH NO. 11. (See illustration No. 6, Special Publication No. 14.)

ZENITH TELESCOPE NO. 4. Troughton & Simms, makers; purchased, 1849; reconstructed in C. & G. S. Office, 1891. (See illustration No. 13, Special Publication No. 14.)

DAVIDSON MERIDIAN TELESCOPE NO. 3. Designed and constructed in the C. & G. S. Office. (See sketch No. 28, C. S. Report for 1867.)

TROUGHTON REPEATING CIRCLE. Made by Troughton in 1814. (See figure 31.)

COMPASS DECLINOMETER NO. 7. (Designed and constructed in C. & G. S. Office, 1914.)

SHIP'S DIP CIRCLE NO. 32. Made by Dover, 1903; Lloyd-Creak Model. (See illustration No. 1, App. No. 3, C. & G. S. Report, 1904.)

Bache Magnetometer. Made by Gambey; employed in magnetic survey of Pennsylvania, 1840–1843; first State magnetic survey made in the United States. (See figures 32 and 33.)

Magnetometer No. 17. Designed and constructed in C. & G. S. Office, 1893. (See fig. 3, Directions for Magnetic Measurements.)

Bache-Wurdemann Compensation Base Apparatus. Designed and constructed in C. S. Office, 1845; employed from 1847 to 1873. (See figure 34.)

Schott Five-Meter Compensation Base Apparatus. Designed and constructed in C. & G. S. Office, 1880–1881. (See figure 35.)

Secondary Base Bar No. 13. Designed and constructed in C. & G. S. Office, 1891; employed, 1891 to 1897. (See figure 36.)

Eimbeck Duplex Base Bar. Designed and constructed in C. & G. S. Office, 1893. (See illustration No. 5, App. No. 11, C. & G. S. Report, 1897.)

Section of Invar Base Tape, Held by Tape Stretchers. C. & G. S. design. (See illustrations Nos. 4 and 5, App. No. 14, C. & G. S. Report, 1910.)

Invar Base Tape. Introduced in 1906. (See illustration No. 1, Special Publication No. 14.)

Theodolite, Twelve Inch No. 168. Type now in use, introduced in 1893. (See illustration No. 2, Special Publication No. 19.)

Theodolite, Twenty Inch, No. 4. Made by Troughton & Simms. Use of this type discontinued in 1898. (See figure 37.)

Theodolite, Twenty-Four Inch, No. 2. Made by Troughton in 1814. (See figure 38.)

Vertical Circle, Eight Inch, No. 109. Made by Brunner. (See illustration No. 5, Special Publication No. 19.)

Tittmann Vertical Collimator No. 6. Designed and constructed in C. & G. S. Office. (See illustration No. 3a, Special Publication No. 19.)

Heliotrope. Type now in use. (See illustration No. 3b, Special Publication No. 19.)

Signal Lamp, Kerosene. Old type, discontinued.

Signal Lamp No. 101, Acetylene. Designed and constructed in C. & G. S. Office, in 1905. (See illustration No. 3c, Special Publication No. 19.)

Signal Lamp No. 150, Electric. Designed and constructed in C. & G. S. Office in 1916.

Batteries for Signal Lamps.

Theodolite, Seven Inch, No. 263. Made by Berger & Sons, 1913. (See illustration No. 19, Special Publication No. 14.)

Theodolite, Four Inch, No. 257. Made by Berger & Sons, 1911. (See illustration No. 20, Special Publication No. 14.)

Photographs of the Tide-Predicting Machine No. 2. Designed and constructed in C. & G. S. Office; completed in 1910. (See illustration No. 14, Special Publication No. 23, and illustrations Nos. 6 to 14, Special Publication No. 32.)

Ship's Bell. From steamer *McArthur*, first Coast Survey steamer built on the Pacific coast; built in 1876; retired from service in 1915.

Tide-Predicting Machine No. 1. Designed and constructed in C. & G. S. Office; used from 1882 to 1912. (See illustrations Nos. 27–31, App. 10. C. & G. S. Report 1883; also illustration No. 5, Special Publication No. 32.)

Mean Time Chronometer No. 1829.

Taffrail Log.

Deep-Sea Sounding Apparatus. Bassnett model.

Current Meter. Ekman model.

Ship's Clock.

Sounding Clock.

Lead and Sounding Line.

Tide-Gauge Sheet.

Sheet from Tide-Predicting Machine. (See illustration No. 15, Special Publication No. 32.)

C. & G. S. Tide Tables, 1855 to 1916. Second and latest editions of this publication.

Hydrographic Sextant No. 418. Made by Heath & Son, 1915.

Registering Sheaves.

Ship's Compass No. 25052. Ritchie Liquid Compass model.

Boat Compass.

Automatic Tide Guage No. 94. Keuffel & Esser, makers, 1910; type of instrument designed in Coast Survey. (See illustrations Nos. 4 and 5, App. No. 7, C. & G. S. Report 1897.)

Three-Arm Protractor.

Court's Protractor.

Hilgard Optical Densimeter. Designed in C. & G. S. Office.

Sounding Tubes. Tanner-Blish model.

Hydrographic Theodolite.

Map of Rock Creek Park, D. C. Made by C. & G. Survey.

Model of Rock Creek Park, D. C. Made by C. & G. Survey.

Phototopographic Camera No. 10. Berger & Sons, makers, 1904.

Plane Table and Alidade. Modern type. (See illustration No. 1, App. 7, C. & G. S. Report, 1905.)

Plane Table and Alidade. Old type.

Telemeter Rod. Old type. (See illustration No. 4, App. No. 7, C. & G. S. Report 1905.)

Telemeter Rod. New type.

Mendenhall Half-Second Pendulum. Designed and constructed in C. & G. S. Office, 1891. (See illustration No. 18, Special Publication No. 23.)

Bessel Pendulum. Constructed by Repsold, 1874–1875; used for observations in Europe and the United States between 1875 and 1878. (See illustration No. 28, App. 15, C. & G. S. Report, 1876.)

Pendulums, Three-Old Types. Peirce, or yard, pendulum, used in Caroline Islands, 1883, and in Hawaii, 1886; Kater pendulum No. 9, used in Hoosac Tunnel work; Silver Kater pendulum. (See illustration No. 20, Special Publication No. 23.)

Geodetic Level No. 6 (Intermediate Type). Designed and constructed in C. & G. S. Office in 1898. (See illustrations Nos. 7 and 8, App. No. 8, C. & G. S. Report 1899.)

Fischer Geodetic Level No. 8. Designed and constructed in C. & G. S. Office; in use 1899–1916. (See illustrations Nos. 1 and 2, Special Publication No. 18.)

Tittmann Geodetic Level No. 1. Designed and constructed in C. & G. S. Office; in use 1879 to 1899. (See illustration No. 52, App. No. 15, C. & G. S. Report 1879.)

Geodetic Level Rod. Old type. (See illustration No. 53, App. No. 15, C. & G. S. Report 1879.)

Geodetic Level Rod. New type. (See illustration No. 3, Special Publication No. 18.)

Case of Small Instruments, Views, and Illustrations, Including an Engraved Copper Plate by J. M. Whistler.

Sample Record Books, Computations and Publications of the C. & G. Survey.

War Maps, 1861–1865. Morris Island, from early Coast Survey reconnoissance and additions by Confederate engineers; plan and views of Confederate defenses, Coast of South Carolina; sketch of the approach of Nineteenth Army Corps to Fisher's Hill; plan of Fort Jackson; defenses of Charleston, S. C.; North Carolina, showing approaches to Wilmington; Charleston Harbor; battle field of Chickamauga; map of eastern Virginia, 1863; map of the ground of occupation and defense of the division of the United States Army in Virginia; North Atlantic Squadron plan of attack on Fort Fisher; Chattanooga and vicinity; military map of southeastern Virginia; battle ground of Pleasant Hill; reconnoissance of the vicinity of New Iberia; approaches to New Orleans by the Bay of Atchafalaya and the New

Orleans & Opelousas Railroad; map of the ground of occupation and defense of the division of the United States Army in Virginia; Grand Gulf, Mississippi River; approaches to Fort Butte La Rose; approaches to Vicksburg; United States forces against Vicksburg; Franklin, La.

CHARTS. Panama Canal and approaches, 1915; Colon Harbor, 1915; Western coast of the United States from Monterey to Columbia River, 1851, in three sheets; Chesapeake Bay entrance, 1915; Delaware Bay, 1915; Hampton Roads, 1915; Potomac River, Mattawoman Creek to Georgetown, 1915; Isla de Puerto Rico, 1848, Spanish; Porto Rico, 1916; San Juan de Puerto Rico, 1868, Spanish; San Juan Harbor, 1915; Pacific coast, San Francisco to Cape Flattery, 1915; Pacific coast, San Diego to Point St. George, 1916; New York Harbor, 1915; New York Harbor, 1775 (Des Barres); Harbor of New York, 1840 (Edmund Blunt); New York Bay and Harbor, 1845; New York City and environs, 1860 (map); Atlantic coast, Chesapeake Bay to Florida, 1655; San Francisco Bay, 1916; San Francisco entrance and bay, 1850 (Cadwalader Ringgold, U. S. N.); San Francisco entrance, 1915; Dixon entrance to Head of Lynn Canal, 1910; Coast of Northwest America, 1798 (Vancouver); Sitka Harbor, 1911; Sitka, 1850 (British); Narragansett Bay, 1915; The Harbor of Rhode Island and Narragansett Bay, 1776 (British); Hawaiian Islands, 1913; Honolulu Harbor, 1916; Boston Harbor, 1775 (British); Boston Harbor, 1915; Cape St. Elias to Shumagin Islands, 1914; Northwestern America, 1867; Philippine Islands, 1915; Manila and Cavite Harbors, 1913; Guam Island Harbor, 1915; Baltimore Harbor, 1915; Frenchmans Bay, 1915; Galveston entrance, 1915; Portland Harbor, 1915.

ATLANTIC NEPTUNE CHARTS.

WIRE-DRAG MODEL. (See illustration No. 13. Special Publication No. 23.)

ORIGINAL HYDROGRAPHIC SHEET, NO. 1, LONG ISLAND SOUND, 1837.

ORIGINAL SHEETS. Hydrography of New Bedford Harbor; wire-drag sheet of approaches to Penobscot Bay, 1913.

SECTIONS OF CHARTS OF VARIOUS DATES, SHOWING CHANGES IN SHORE LINE. Approaches to New York, 1913; approaches to New York, 1914.

ALUMINUM PLATE WITH IMPRESSION OF CHART.

LITHOGRAPHIC STONE.

COPPER PLATE OF CHART, ALTO.

COPPER PLATE OF ENGRAVED CHART.

CHART AND MAPS. Cape Sable to Cape Hatteras, 1915; Phototopographic reconnoissance of the Chilkat River Valley, 1898; West Side of Nagai Island, 1915.

DESCRIPTIVE CARDS OF CHART MAKING, COMPUTING, COMPILING AND DRAWING, ENGRAVING, ELECTROTYPING, AND PRINTING.

LARGE MAP OF THE UNITED STATES, SHOWING PROGRESS OF SURVEYING OPERATIONS

MAP OF ALASKA, SHOWING CONDITION OF HYDROGRAPHIC SURVEYS.

ELEVEN SMALL BASE MAPS SHOWING PROGRESS OF ALL SURVEYING OPERATIONS.

MILLIONAIRE ELECTRIC COMPUTING MACHINE.

TABLE SHOWING NUMBER OF CHARTS PRINTED ANNUALLY AT 10-YEAR PERIODS; CARDS SHOWING DUTIES OF THE COAST AND GEODETIC SURVEY, AND WHAT THE SURVEY HAS DONE AND IS DOING.

MAPS OF THE UNITED STATES SHOWING DISTRIBUTION OF MAGNETIC AND ASTRONOMICAL STATIONS.

MAGNETIC ISOGONIC CHART OF THE UNITED STATES FOR 1915.

PUBLICATIONS FOR DISTRIBUTION.

ORIGINAL SHEETS. South coast of Long Island, 1835; Blackwells, Wards, and Randalls Islands, 1885.

COLLECTION OF ANNUAL REPORTS OF THE SUPERINTENDENTS OF THE COAST AND GEODETIC SURVEY.

SIX STANDS OF PHOTOGRAPHS ILLUSTRATIVE OF SCENERY, METHODS, PARTY OPERATIONS, AND EXPERIENCES. C. & G. S. Records.

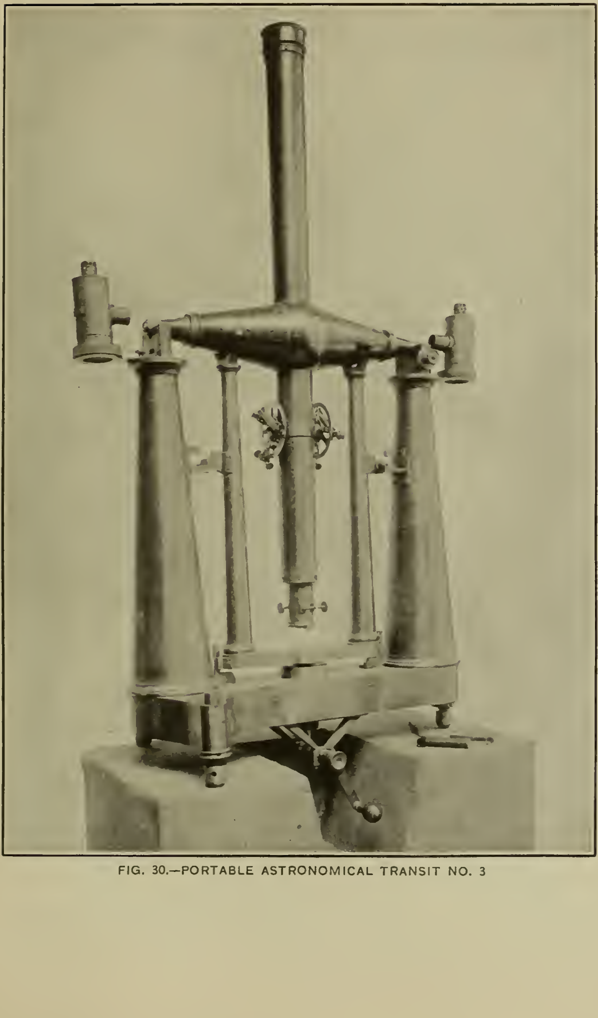

FIG. 30.—PORTABLE ASTRONOMICAL TRANSIT NO. 3

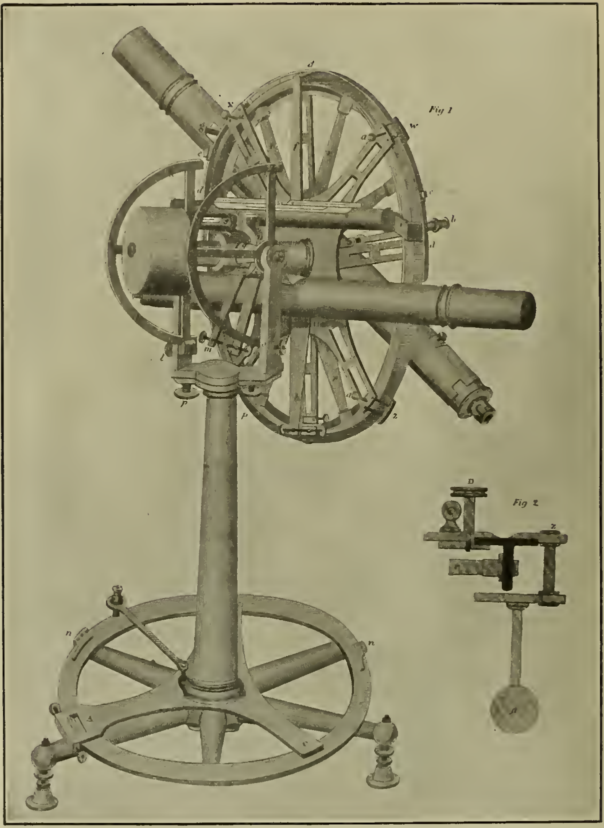

FIG. 31.—TROUGHTON REPEATING CIRCLE

Reproduced from the Transactions of the American Philosophical Society, 1825

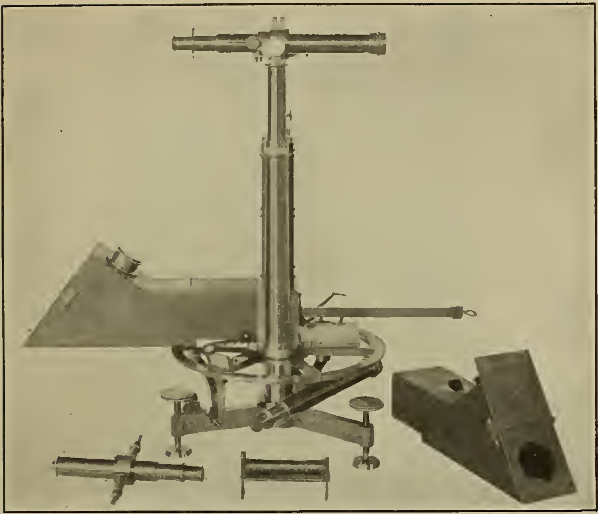

FIG. 32.—BACHE MAGNETOMETER WITH ONE SECTION OF MAGNET HOUSE REMOVED

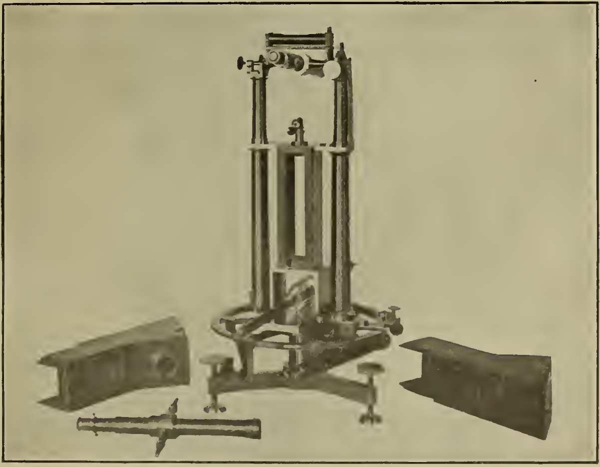

FIG. 33.—BACHE MAGNETOMETER WITH BOTH SECTIONS OF MAGNET HOUSE REMOVED

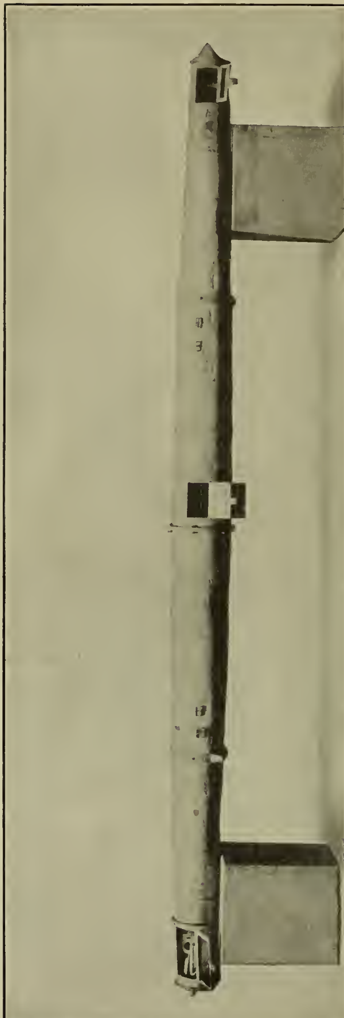

FIG. 34.—BACHE-WURDEMAN COMPENSATING BASE APPARATUS

FIG. 35.—SCHOTT FIVE-METER COMPENSATION BASE BAR

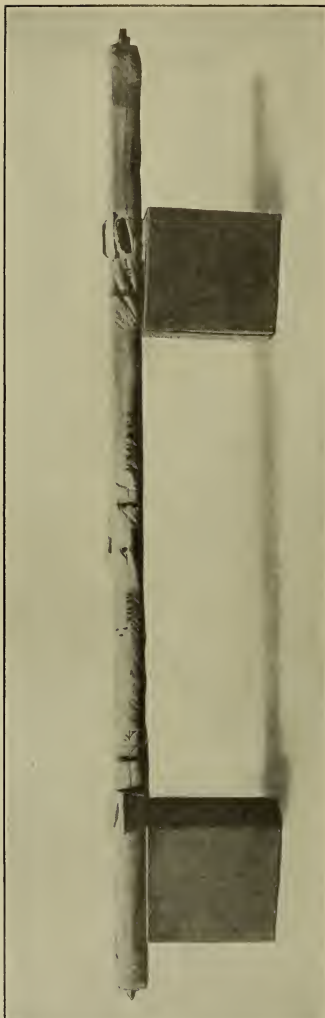

FIG. 36.—SECONDARY BASE BAR NO. 13

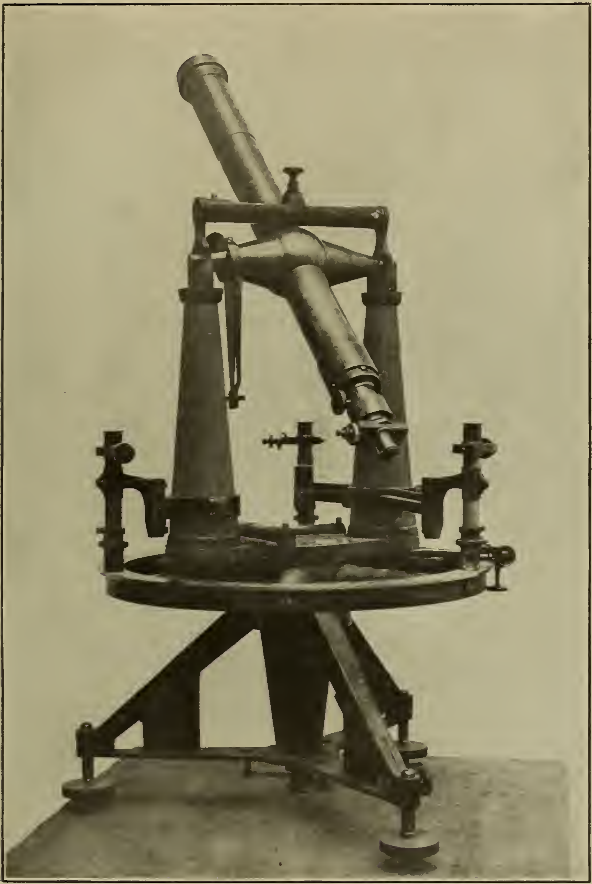

FIG. 37.—TWENTY-INCH THEODOLITE NO. 4. MADE BY TROUGHTON AND SIMMS

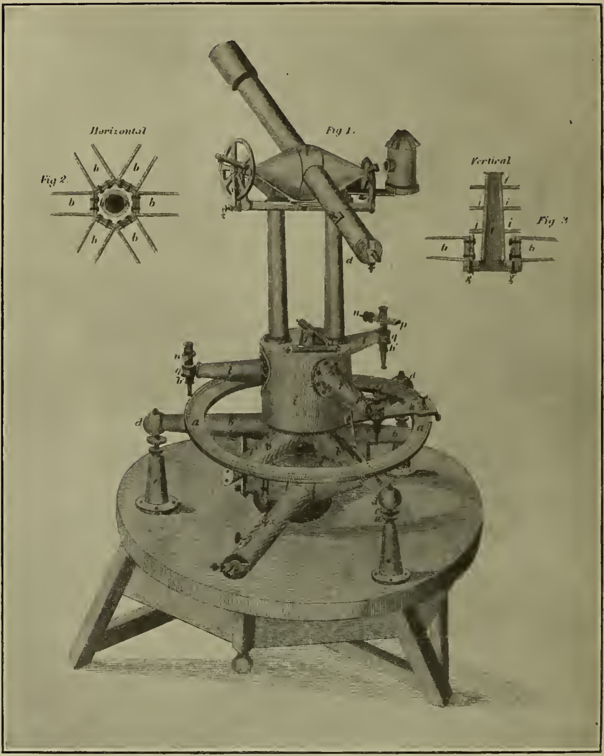

FIG. 38.—TWENTY-FOUR INCH THEODOLITE NO. 2. MADE BY TROUGHTON IN 1814

Reproduced from the Transactions of the American Philosophical Society, 1825

ORIGIN OF THE COAST AND GEODETIC SURVEY

The first measure for the survey of the coast of the United States was the act of February 10, 1807, authorizing the President to make the necessary preparations and enter on a survey of the coast of the United States, for which purpose an appropriation of $50,000 was included.

The immediate result of this act was a circular letter addressed to a number of scientists whose reputations seemed to indicate qualifications for the work and the consequent choice of the scheme submitted by Ferdinand Rudolph Hassler, one of the originators of the Geodetic Survey of Switzerland, for the plan of operations, and the approval of Messrs Hassler and Isaac Briggs, the latter afterwards distinguished by his connection with the construction of the James and Kanawha Rivers and the Erie Canal, for the execution of the work.

Because of the unsettled condition of the international affairs of the Nation, nothing further was done until 1811, when Professor Hassler was requested to prepare designs and estimates for the necessary instruments required to put the Survey in operation and, these having been approved by the governmental scientific advisers, he was given a commission to travel abroad in Europe for the purpose of contracting for the purchase and the supervision of the construction of the apparatus. This duty was delayed in execution by the outbreak of the War of 1812, and Hassler's return from his accomplished mission did not occur until October 22, 1815.

In 1816 Congress reenacted the appropriation provision for the Survey, and Mr. Dallas, Secretary of the Treasury, by direction of the President, on August 3, approved the detailed plans for operations presented by Mr. Hassler on January 5, same year, and appointed him Superintendent for the Survey of the Coast, the compensation under this appointment dating from June 18, 1816.

DEPARTMENTS TO WHICH SURVEY HAS BEEN ATTACHED

Treasury	June 18, 1816, to Apr. 29, 1818.
Do	July 10, 1832, to Mar. 11, 1834.
Navy	Mar. 12, 1834, to Mar. 27, 1836.
Treasury	Mar. 27, 1836, to July 30, 1903.
Commerce and Labor	July 1, 1903, to Mar. 3, 1913.
Commerce	Mar. 4, 1913.

PRINCIPAL ACTS OF CONGRESS LEGISLATING FOR THE SURVEY

ORGANIC ACT FOR CREATION OF SURVEY OF COAST

CHAP. VIII.—*An Act to provide for surveying the coasts of the United States.*[1]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the President of the United States shall be, and he is hereby authorized and requested, to cause a survey to be taken of the coasts of the United States, in which shall be designated the islands and shoals, with the roads or places of anchor-

[1] Stat. L., vol. 2, p. 413.

age, within twenty leagues of any part of the shores of the United States; and also the respective courses and distances between the principal capes, or head lands, together with such other matters as he may deem proper for completing an accurate chart of every part of the coasts within the extent aforesaid.

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

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

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

Approved, February 10, 1807.

ACT PROVIDING FUNDS FOR PURCHASE OF SCIENTIFIC EQUIPMENT FOR SURVEY OF THE COAST

CHAP. XXXIII.—*An Act making appropriations for the support of Government for the year one thousand eight hundred and twelve.*[1]

* * * * * * *

For surveying the coast of the United States, being the balance of a former appropriation carried to the credit of the surplus fund, *forty-nine thousand two hundred and eighty-four dollars and thirty-five cents.*

* * * * * * *

Approved, February 26, 1812.

ACT FOR SUPPLY OF FUND FOR FIRST FIELD WORK OF THE SURVEY

CHAP. CXX.—*An act making appropriations for rebuilding light-houses and for completing the plan of lighting them, according to the improvements of Winslow Lewis, for placing beacons and buoys, for preserving Little Gull Island, and for surveying the coast of the United States.*[2]

* * * * * * *

For defraying the expense of surveying the coast of the United States, fifty-four thousand four hundred and twenty dollars and fifty-seven cents.

* * * * * * *

Approved, April 27, 1816.

ACT SUSPENDING OPERATIONS OF COAST SURVEY

CHAP. LVIII.—*An Act to repeal part of the act, entitled "An Act to provide for surveying the coasts of the United States."*[3]

Be it enacted by the Senate and House of Representatives of the United States of America, in Congress assembled, That so much of the third section of the act, passed the tenth day of February, one thousand eight hundred and seven, entitled "An act to provide for surveying the coasts of the United States," as authorizes the employment of other persons in the execution of said act, than the persons belonging to the army and navy, be, and the same is hereby, repealed.

SEC. 2.—*And be it further enacted,* That all instruments and property of the United States, and all surveys, drafts, notes, charts, maps, and documents, in any wise belong-

---

[1] Stat. L., vol. 2, p. 690. [2] Stat. L., vol. 3, p. 316. [3] Stat. L., vol. 3, p. 425.

ing to the survey of the coasts, be deposited in such place as the President of the United States shall direct.

Approved, April 14, 1818.

ACT FOR RESUMPTION OF OPERATIONS OF SURVEYING THE COAST

CHAP. CXCI.—*An Act to carry into effect the act to provide for a survey of the coast of the United States.*[1]

Be it enacted by the Senate and House of Representatives of the United States of America, in Congress assembled, That for carrying into effect the act, entitled "An act to provide for surveying the coasts of the United States," approved on the tenth day of February, one thousand eight hundred and seven, there shall be, and hereby is, appropriated, a sum not exceeding twenty thousand dollars, to be paid out of any money in the treasury not otherwise appropriated; *and the said act is hereby revived,* and shall be deemed to provide for the survey of the coasts of Florida, in the same manner as if the same had been named therein.

SEC. 2. *And be it further enacted,* That the President of the United States be, and he is hereby authorized, in and about the execution of the said act, to use all maps, charts, books, instruments, and apparatus, which now, or hereafter may belong to the United States, and employ all persons in the land or naval service of the United States, and such astronomers and other persons as he shall deem proper: *Provided,* That nothing in this act or the act hereby revived, shall be construed to authorize the construction or maintenance of a permanent astronomical observatory.

Approved, July 10, 1832.

ACT FOR PURCHASE OF FIRST STEAMER FOR EMPLOYMENT IN SURVEY OF WESTERN COAST OF THE UNITED STATES

CHAP. LXXVII.—*An Act making Appropriations for Lighthouses, Light-Boats, Buoys, &c., and providing for the Erection and Establishment of the same, and for other purposes.*[2]

* * * * * * *

SEC. 8. *And be it further enacted, That there be, and hereby is, appropriated the sum of one hundred and fifty thousand dollars to purchase a steamer to be employed in the coast survey upon the Pacific coast,* and used, if deemed expedient, in designating the sites of the several lighthouses provided for in California.

* * * * * * *

Approved, September 28, 1850.

FIRST ACT FOR EXTENSION OF OPERATIONS OF THE COAST SURVEY TO WESTERN COAST OF THE UNITED STATES

CHAP. XC.—*An Act making Appropriations for the Civil and Diplomatic expenses of Government for the Year ending the thirtieth of June, eighteen hundred and fifty-one, and for other purposes.*[3]

* * * * * * *

For survey of the coast of the United States, including compensation to superintendent and assistants, one hundred and eighty-six thousand dollars.

For continuation of the survey of reefs, shoals, keys, and coast of South Florida, by the superintendent of the coast survey, thirty thousand dollars.

For continuing the survey of the western coast of the United States, forty thousand dollars.

* * * * * * *

Approved, September 30, 1850.

[1] Stat. L., vol. 4, p. 570. [2] Stat. L., vol. 9, p. 504. [3] Stat. L., vol. 9, p. 540.

ACT FOR EXTENSION OF GEODETIC OPERATIONS INTO INTERIOR OF THE UNITED STATES AND FOR SUPPLYING GEOGRAPHIC POSITIONS FOR STATE SURVEYS

CHAP. CXIV.—*An Act making Appropriations for sundry civil Expenses of the Government for the fiscal Year ending June thirty, eighteen hundred and seventy-two, and for other Purposes.*[1]

* * * * * * *

For extending the triangulation of the coast survey so as to form a geodetic connection between the Atlantic and Pacific coasts of the United States, including compensation of civilians engaged in the work, fifteen thousand dollars: Provided, That the triangulation shall determine points in each State of the Union which shall make requisite provisions for its own topographical and geological surveys.

* * * * * * *

Approved, March 3, 1871.

ACT CHANGING TITULAR DESIGNATION OF SURVEY

CHAP. 359.—*An act making appropriations for sundry civil expenses of the government for the fiscal year ending June thirtieth, eighteen hundred and seventy-nine, and for other purposes.*[2]

* * * * * * *

COAST AND GEODETIC SURVEY

Survey of the Atlantic and Gulf coasts: For every purpose and object necessary for and incident to the continuation of the survey of the Atlantic and Gulf coasts of the United States, the Mississippi, and other rivers, to the head of ship-navigation or tidal influence; soundings, deep-sea temperatures, dredgings, and current-observations along the above-named coasts, and in the Gulf of Mexico and the Gulf Stream, including its entrance into the Gulf of Mexico and east end of the Caribbean Sea; the triangulation toward the Western coast and furnishing points for State surveys; the preparation and publication of charts, the Coast Pilot, and other results of the work, with the purchase of materials therefor, including compensation of civilians engaged in the work, three hundred thousand dollars.

* * * * * * *

Approved, June 20, 1878.

ACT FOR INCEPTION OF ALASKAN BOUNDARY SURVEY

CHAP. 1069.—*An act making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and eighty-nine, and for other purposes.*[3]

* * * * * * *

Alaska boundary survey: For expenses in carrying on a preliminary survey of the frontier line between Alaska and British Columbia, in accordance with plans or projects approved by the Secretary of State, including expenses of drawing and publication of map or maps, twenty thousand dollars, said sum to continue available for expenditure until the same is exhausted.

* * * * * * *

Approved, October 2, 1888.

[1] Stat. L., vol. 16, p. 508. [2] Stat. L., vol. 20, p. 215. [3] Stat. L., vol. 25, p. 515.

ACT EXTENDING OPERATIONS OF THE COAST AND GEODETIC SURVEY TO HAWAIIAN ARCHIPELAGO, THE PHILIPPINE ARCHIPELAGO, AND OTHER ISLANDS IN THE PACIFIC OCEAN

CHAP. 424.—*An act making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, nineteen hundred, and for other purposes.*[1]

* * * * * * *

For surveys and necessary resurveys of the Pacific coast, including the Hawaiian Islands and Alaska and other coasts on the Pacific Ocean under the jurisdiction of the United States, to be immediately available, and to remain available until expended: Provided, That not more than twenty-five thousand dollars of this amount shall be expended outside of Alaska and the Pacific coast of the United States, seventy thousand dollars.

* * * * * * *

Approved, March 3, 1899.

RESOLUTION ACCEPTING INVITATION TO MEMBERSHIP IN INTERNATIONAL GEODETIC ASSOCIATION

(No. 3.) *Joint resolution accepting the invitation of the Imperial German Government to the Government of the United States to become a party to the International Geodetic Association.*[2]

Whereas, the Government of the United States has been invited by the Imperial German Government to become a party to the International Geodetic Association: Therefore,

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the President be, and he is hereby, requested and authorized to accept said invitation, and that he is hereby authorized and requested to appoint a delegate, who shall be an officer of the United States Coast and Geodetic Survey, to attend the next meeting of said International Geodetic Association, but no extra salary or additional compensation shall be paid to such by reason of such attendance.

Approved, February 5, 1889.

DOCUMENTS PERTAINING TO THE EARLY HISTORY OF THE UNITED STATES COAST AND GEODETIC SURVEY

CIRCULAR LETTER ADDRESSED BY ALBERT GALLATIN, SECRETARY OF THE TREASURY, TO EMINENT SCIENTISTS REQUESTING PLAN FOR SURVEY OF THE COAST OF THE UNITED STATES

(Copy)

TREASURY DEPARTMENT,
March 25, 1807.

SIR: The President of the United States being authorized by an Act of last Session to cause the whole of the Coast of the said States, together with the adjacent Shoals and Soundings, to be surveyed, it is his intention that the work should be executed with as much correctness as can be obtained within a reasonable time: and he has directed me to apply to you, requesting that you would have the goodness to suggest the outlines of such a plan as may, in your opinion, unite correctness and practicability.

As each nautical Survey of the Shoals and Soundings presupposes a knowledge of the position of certain points on the Coast, it seems to me that the work should consist of three distinct parts, viz:

1st. The ascertainment by a series of astronomical observations, of the true position of a few remarkable points on the Coast; and some of the Light Houses placed on the principal Capes, or at the entrance of the principal harbours, appear to be the most

[1] Stat. L., vol. 30, p. 1083. [2] Stat. L., vol. 25, p. 1019.

eligible places for that purpose, as being objects particularly interesting to navigators, visible at a great distance, and generally erected on the spots on which similar buildings will be continued so long as navigation exists. 2d. A trigonometrical survey of the Coast between those points of which the position shall have been astronomically ascertained; in the execution of which survey, the position of every distinguishable permanent object should be carefully designated, and temporary Beacons be erected at proper distances, on those parts of the Coast on which such objects are rarely found. 3dly. A Nautical Survey of the Shoals and Soundings off the Coast, of which the trigonometrical Survey of the Coast itself, and the ascertained positions of the Light Houses and other distinguishable objects, would be the basis, and which would therefore depend but little on any astronomical observations made on board the Vessels employed on that part of the work.

But this is submitted to your consideration, not for the purpose of pointing out any plan in preference to another, but only in order to shew the view which we have taken of the subject, and the degree of accuracy which we are desirous of attaining.

I will only add, that the greatest practical difficulties which have heretofore occurred, relate to what I call the Nautical Survey; and on that part of the subject the following enquiries have arisen. Can a correct survey be taken with one Vessel alone? Can Angles be taken with sufficient correctness from on board a Vessel, so as to ascertain its position in relation to three visible objects on shore? Or is it necessary that the Vessel's position at the time of taking any particular sounding should be ascertained by observers on shore? And many other which an examination of the Subject will naturally suggest to you.

Permit me also to ask, whether you know any persons whom you might recommend as capable of acting in the different parts of the work.

I have the honor to be,

Respectfully, Your Obed^t. Serv^t.,

(Indorsements)

March 25, 1807

Robert Patterson.
Andrew Ellicott.
M. S. Hasler (Sic).
John Garnett.
Isaac Briggs.
R^t Rev^d James Madison.
Joshua Moore.

Recorded in Light House Letter Book No. 3, page 383.

Sketch of a letter to sundry persons on the subject of surveying the coast. Submitted to the President for correction.

A. G.

Approved

(Sd.) TH. JEFFERSON,
March 25. 07.

HASSLER'S PLAN FOR SURVEY OF COAST, APPROVED BY PRESIDENT JEFFERSON

(Translation from original manuscript, in French)

PHILAD^a. *Apr. 2. 1807.*

SIR: Honored with your letter of the 25. March last, I take the liberty of answering to the confidence you have been pleased to show me, and to communicate my ideas upon the best methods to be pursued in effecting the survey of the coast as desired by the government.

The course which you have traced in your letter for this work is very just, and contains its true principles. Permit me merely to extend them, in applying some considerations more in detail.

To effect this survey with the greatest possible exactness the course to be pursued would be the following.

To measure upon the whole extent of the coast with a "circle repetiteur a deux lunettes," of one foot diameter, (or for want of that an English theodolite of at least the same diameter, and capable of multiplying angles), a chain of triangles, the sides of which should be about 60 or 100 thousand feet and established upon bases measured with the known means of exactness.

All the astronomical observations and deductions which circumstances may require, or which may be necessary, ought to be made in the course of the work, at convenient points, as well for determining the latitude and longitude of those points, as the azimuths of the sides of the triangles; making use principally of the sun and polar star for the last two objects, and of momentary signals (ex. gr. rockets or the discharge of fire-arms) made at an intermediate point between two observers. At the same time as many secondary points and even simple directions ought to be ascertained as can be effected without impeding the principal design. This measure, as you have observed, would fix the positions of light-houses, towns, villages, and other principal points on the coast, and with a sufficient number of signals erected at suitable points, would provide for the continuation of the surveys in detail.

The results might be laid down, according to the difference of the meridians and parallels, upon large paper, divided into plats as convenience might require, and accompanied with a table of longitudes, latitudes, distances, and azimuths.

It would be advantageous that there should always be together two observers, and a skilful person in addition to make signals, &c. One of these must have the direction, in order to avoid the delays that might arise from a difference of opinion respecting the operations. The same observation will apply to the formation of a central point for all the works, under a man who to mathematical science shall unite a knowledge of the geography of the country. Under him would be made the calculations, and the reductions of the measurements at large, the distribution, verification and collection of all the details of the work.

The journals ought to be kept with such clearness that the observers after their return might give them to other persons conversant with this business, to make up from them the results. They ought to be in folio and the opposite of each page of observations devoted entirely to remarks, designs, descriptions of stations, plans of operations, even notices of the weather, etc.

A good method of making signals is very important, in order to attain a clear and certain view, and consequently exactness in the observation, and without a waste of time. I would propose to make use of triangular, equilateral pyramids of from 10 to 30 feet in height (according to the place where they are to be used) of a proportionate base, composed of three posts fixed in the earth, uniting at the top, from which a strong pole should proceed, bearing a ball of one foot diameter composed of potter's clay and covered with a good yellow varnish, or any other substance forming a point of reflection, or it might be composed of a globe of 1½ or 2 feet diameter formed of barrel hoops covered with white or black cloth according as the projection in relation to the observer falls upon the surface of the earth, in the sky or in the water. For night signals, large Argand lamps with wicks of six inches or more in diameter according to the distance should be fixed upon these stations.

In low grounds, or marshes, elevated signals will be indispensable. In the centre of the pyramid may be placed an apparatus, easily transported, on which to support the instrument and the observers separately. In this way observations may be taken firmly enough, even in swampy situations, especially if the "circle repetiteur a duex lunettes" is used.

In woods the signals may be erected upon some point a little more elevated, or connected with the highest trees. They may be so constructed that an observer can mount upon them to take angles with a reflecting instrument, supposing that their measure can not be obtained from the other angles of the triangle, measured with the great instrument.

The persons charged with the survey in detail, to whom the plats and tables of observations above mentioned are distributed, should take these given points as bases, from whence to fill up their respective portions of survey as fully as may be desired, either with small theodolites, the "planchette or sextant," compass, &c., according as local circumstances or the means they may have within their reach will permit.

The soundings may be taken by a small vessel (a pilot boat, for instance) with an observer on board, following and assisting the surveyor tracing the coast. There ought to be two shallops in company, for the accommodation of the observers, to serve in care of signals, &c. The vessel stopping every time its direction is changed, or when a remarkable sounding is taken, the observer on board should measure with a sextant the angle between the station of the observer on the shore (to whom he might make a signal), and some other convenient point. At the same time the angles between the vessel and some determinate point might be observed from the shore. The course of the vessel thus laid down, independently of the observations of the log and compass, which might nevertheless be made, would determine the currents, if there were any, by their difference. The nautical survey might thereby be either disregarded, or, in case of need, where that upon the coast could not be made, might be substituted in its stead, as convenience should require, always grounding it, however, upon the latter. It would be proper that the surveyors should be assisted by a pilot, or by some other person acquainted with the coast, who should point out to them remarkable objects, names of places, &c.

In these surveys, the problem of the three points, of which you have made mention, might often be applied, but being liable to uncertainty (from a trifling error in the observation otherwise of no consequence) when the point to be found approaches near the periphery of the circle which passes through the three points given, and in which case it becomes indeterminate, it can be given as a general instruction to be pursued. The observer ought, before trusting to it, to see, by laying down his situation, if it will answer.

The place of an observer may also be determined under given latitudes by a single line the length and direction of which with reference to the meridian is given by the measurement of an angle at the point sought, and of an azimuth.

The determination of the azimuth ought also to be made in these details, by observations of the sun and of the pole star, and not taken by the compass, which will serve only for the least important.

It would be advantageous for the surveyors employed on these details to form for their use an instructive set of various problems, which should show in what cases the application of one or the other is favorable or not: with the best methods of making the observations, calculations, constructions, &c., the whole adapted to the method of survey which shall be followed: perhaps even tables might be joined to it.

Such a system of operations, being susceptible of every degree of exactness that can be desired (in great triangles to $\frac{1}{30000}$), and carrying with it its own proof, would give results applicable to every purpose, and would allow a bold course of execution in the surveys in detail, by the frequent occasions afforded for verifying the work. Without these, this part of the business always runs into a much greater length than is apprehended at the outset. The nearer the system adopted may approach to one like this, the greater exactness will it give, and the more useful will be its results.

If such a plan of operation is considered as too extensive under local circumstances, the following might be substituted for it. Instead of the triangular measurement above mentioned, resort might be had to the fixing of points of latitude and longitude by means of chronometers and sextants, or "cercles à reflexion," which ought in this case to be of the first quality, and the chronometers always two together. A series of points and signals, systematically placed and distributed, to serve for the purposes of the survey in detail, ought in that way to be determined, as in the preceding method by triangles. Observations of azimuths, even of measured lines, and triangles taken by "instruments à reflexion," should be added to them wherever the occasion might offer, as well for multiplying determinate points and facilitating thereby the surveys in detail as to verify the astronomical observations one by the other mutually. At convenient points, or at those of greatest importance, it would be necessary, by multiplying and varying the observations, to supply the place of the conjunction of a measurement of triangles with the astronomical observations above mentioned.

To supply the defect arising from the impossibility of observing the double meridian altitude of the sun in summer it will be necessary to make use of stars well ascertained, and above all the polestar.

This method tho' not susceptible of all the exactness of the preceding, is however free from the defect of an accumulation of errors; because the determinations are independent of one another. (Latitudes may be ascertained within at least 10 seconds of a degree, and longitudes within at least 2 seconds of time.) Its inconvenience is, that it does not give with the same facility and precision, determinations of the extent of distances, to serve for the surveys in detail; a disadvantage proportioned to the largeness of the scale on which they are desired to be laid down; wherefore for maritime use alone of little consequence.

What has been above said respecting the verification of differences of longitude, by momentary or fixed signals, respecting the journals, the number of persons necessary, is absolutely the form for this method. The surveys in detail might be made in the same manner, as in the preceding system, by disposing in a proper manner for this use, the different measurements and additional determinations mentioned.

The details of the surveys may be effected by extending the last method to them, and alternately even to a nautical survey. But then, that nothing should be omitted, it would be necessary to make all the calculations consecutively after the observations or the advantage would be lost of verifying them, and of drawing proofs from subsequent observations. The same persons employed in making the most essential determinations would also be charged with the smallest details, or would depend upon them in their progress; being compelled to direct or to prepare and furnish the work of the surveyors in detail. Thence, a systematical progress would no longer exist.

The expense of one and the other of the two methods here proposed, may be considered as the same; what one costs in instruments for measuring angles, and in transportation upon land, the other will cost in chronometers, hire of vessels, &c.

The consumption of time is decided, 1. By the season, as it may be more or less favorable to astronomical observations, which are more necessary in the chronometrical survey than in that by the triangles, which may often be measured when astronomical observations cannot be made. 2. By the degree of exactness required in the measurement of the triangles, which will take more time the more careful the observers are required to be. 3. By the greater or less number of observations local circumstances may demand of one or the other method.

The different nature of the coasts, and the number of different objects to be surveyed, on the exterior of the coast (as islands, bays, &c.) may perhaps render preferable for one part of the work, a survey conforming to the first method; and for another, the chronometrical or even a nautical survey. To judge competently of this, local information is necessary, which at present I am not possessed of.

Excuse, Sir, the details and the length into which I have gone: but new yet in this country, I have been able to speak of principles only, and to discuss, not to determine. An acquaintance with the particular views which may enter into consideration, the means both as to scientific knowledge, instruments and persons who can be commanded as well as of the particular obstacles which may occur, are wanting to me: from thence depends the decision as to the preference to be given to one or the other described plan of operations which are in my opinion, the most exact and the most consonant to the general views of the government.

To express myself with greater facility I have taken the liberty of writing through preference, in French.

I have the honor to be with the most profound respect and devotedness,

Your devoted servant,

F. R. Hassler.

FIRST LETTER APPOINTING MR. HASSLER TO SUPERINTENDENCY OF THE COAST SURVEY

Treasury Department,
3d August, 1816.

Sir: The correspondence and documents relative to your being employed as Superintendent of the Survey of the Coast, under the act of Congress respecting that object, have been submitted to the President, and your services are engaged on the following terms:

1st. The whole of your time, labor, talents, and attention, shall be given to the work, as well in relation to the superintendence of the duties to be performed by military or naval officers and assistants, or by draftsmen and engineers, as in relation to the parts of the work which are to be executed by yourself.

2d. You will be provided with competent assistanee of officers and men from the corps of engineers and from the navy, with tents and field equipage, with baggage wagons and horses; and you will have the free use of the public instruments and books for the purposes of the survey.

3d. The party of officers, men, and assistants, accompanying you, will be ordered to conform to your instructions; and all the incidental expenses of the survey which are of a public nature will be defrayed by the government; but your own personal expenses are to be defrayed by you, whether you are employed at home or abroad.

4th. Funds will be placed from time to time, upon your requisition, in the hands of the chief officer accompanying you, to be disbursed, upon your order, in the payment of the expenses of a public nature, and to be accounted for by him at the Treasury once, at least, in every three months.

5th. You will receive in full for all your services a compensation at the rate of 3,000 dollars per annum, and for your personal expenses an allowance at the rate of 2,000 dollars per annum; to commence on the 18th day of June, 1816, and to be paid quarterly at the Treasury upon your drafts.

6th. You will make frequent reports of your progress to this department, and deposit here all the surveys, drafts, notes, charts, maps, journals, and documents in any wise belonging to the survey of the coast; and you will return the public instruments and books to such place as shall be directed, when they are no longer required for the business of the survey.

7th. If at any time it should be necessary to explain the nature and extent of your employment and engagement, your communications to this department, and particularly the articles submitted by you on the 12th of July, 1816, will be resorted to.

It only remains to repeat the President's solicitude for a successful and speedy execution of the great national work which is thus confided to you, and to assure you of the esteem with which

I am, Sir, your most obedient servant,

A. J. Dallas.

Mr. F. R. Hassler.

To the care of Robert Patterson, Esq.

Director of the Mint, Philadelphia.

Copy certified conformable to the original,

F. R. Hassler.

FIRST REPORT ON FIELD OPERATIONS OF THE COAST SURVEY

NEWARK, NEW JERSEY, *23d Nov. 1816.*

MOST HONORED SIR: Herewith I have the honor to forward to you my first report upon the work of the Survey of the Coast, containing the result of all that it was possible to do since the time of my appointment.

I postponed it until now, intending to present in it together all the operations made for the purpose of finding a proper locality for the base line and the system of the first triangle, which, as one of the fundamental works, it is proper to do with full knowledge of the locality and configuration of the country to be surveyed. You will see that circumstances, however, prevented me to do this as fully as I would wish, though I made every possible exertion towards it. It would be very important for the advancement of the work that I should be enabled to make this fall yet the works necessary to arrest fully the plan of operation. I am very desirous to do it, though at this season works in open fields are not without disagreement.

On speaking lately with General Swift upon the manner of providing the necessary assistance for the work of the Survey, which, according to my plans, was intended to be provided by the War Department, the following ideas occurred, which I wish to present to your consideration:

1. For the transport of the instruments, next spring and in future, when the best instruments of the collection will be used, and particular care required for them, the conveying of them by hand of men, which is the best mode, would require such a number of them as could not be spared in the corps of engineers, and would be very expensive; that it would therefore be more advantageous, and even the only practicable way, to have a spring carriage constructed, of proper dimensions and proper arrangement for that purpose, and to furnish it with two horses and a driver, in like manner as it was done in the survey of England, though the operators in that work have recorded in their journal frequent complaints of their theodolite being injured by the conveyance. But the two-feet theodolite of Mr. Troughton, in the Government's collection, is of far better and more secure construction; so that, with proper care, and the slow path naturally adopted in the conveyance, I should think as well this as the other necessary instruments could be well trusted to such a carriage.

2. For baggage and necessary tools, it seemed proper to make use of the wagon and horses which Major Abert has procured as long as they may serve, requesting only a driver to it.

3. For any conveyance of larger bulky things, stands, signals, &c., which will be required only when moving at some distance, or on certain occasions, it would be the cheaper plan to make use of hired assistance.

4. For the measurement of the base line, next spring, the number of men mentioned in my plan for putting the Survey of the Coast into operation is absolutely required. According to General Swift's account, they cannot be spared from the service of the corps of engineers. A certain number of them will also be required for all future times; it will therefore be necessary to provide them by some arrangement. Their numbers will however in part depend on the number of cadets from the Military Academy who will follow the work. When the time of work for next spring draws nearer, and I shall be informed of the means that may be furnished, I shall try to adapt to it as much as possible, and be able to be more precise in this respect.

5. As no carriage like that mentioned in the first article here, nor tents and the other articles, mentioned as requisites in my plan of operation, are present in the military stores, and no expenses authorized for it in the War Department, it might be most proper to furnish Major Abert with instructions and means to procure them.

I have just received a letter from Major Abert, stating that he had been refused funds which he had required for the public expenditure, to enable him to accompany me in the proposed works, and to defray certain expenditures which I had mentioned to him as to be encountered now, because, according to the arrangement of the Treasury Department with me, funds were to be given only upon a request from myself. We are, therefore, stopped in our further proceedings at present.

I take the liberty to state, upon this subject, that this request has been made by me, before I left Philadelphia for reconnoitering, and that I have mentioned the sum of at least 2,000 dollars as necessary to put to his disposition for the different expenses to be encountered before next spring. I have also at the time given in an estimate, naming the items of expenditure, among which I did not comprehend either the maintenance of the soldiers and the horses, or the purchase of horses and wagon, both of which I had considered as part of the requisites to be furnished by the War Department, free of expenditures from the funds of the Survey.

The sum mentioned has been only partially received by Major Abert, as I understand, for which part he will be able to give account; the disbursements hitherto occurred have all been in consequence of travelling for reconnoitering, and some temporary signals; therefore, the items stated in my estimate, and now at hand to be disbursed, remain yet, as they were stated at the time; and if the proposal of article 1st, heretofore, meets your approbation, it will be proper to insert it at the rate of six or seven hundred dollars probably.

I must however observe, that all the estimates in detail which I am obliged to attempt can yet be but extremely vague and uncertain, and that it is impossible to make an accurate estimate before some progress in the work will have furnished me with experience to ground a judgment upon; and as it seems that nothing will be furnished from the military stores, the articles for which I relied upon them must necessarily be added, and augment the disbursement.

Not to be uselessly prolix here, I take the liberty to refer, for all these particulars, to my former plans, letters, and other communications, made at different times, and a letter which General Swift has written to the War Department in consequence of our conversation.

F. R. Hassler.

The Hon. W. H. Crawford,
Sec. of the Treasury, Washington.

LETTER OF SECRETARY OF THE TREASURY CONTAINING SECOND APPOINTMENT OF F. R. HASSLER AS SUPERINTENDENT OF COAST SURVEY AND CONTAINING INSTRUCTIONS FOR RENEWAL OF FIELD OPERATIONS

Treasury Department,
August 9th, 1832.

Sir: With the President's approbation you have been appointed to make, under the superintendance of this department, the Survey of the Coast of the United States, directed by the acts of the 10th of February, 1807, and 10th of July, 1832.

The act last mentioned having authorized the employment of other persons as well as those in the land and naval service, such assistants of either description as may be necessary in the work will be provided at your request.

Funds will be placed from time to time, upon your requisition, in the hands of one of your assistants, to be disbursed for such expenses of a public nature as may be properly chargeable to the appropriation for the Survey of the Coast; and he will render his accounts, approved by you, quarterly to the first Auditor.

Those expenses of the persons in the military and naval service employed in the Survey which are chargeable to military and naval appropriations, will be defrayed by the officers of the respective departments, and accounted for under the direction of those departments.

You will receive, in full for all your services, a compensation at the rate of $3,000 per annum, and for all your personal expenses an allowance at the rate of $1,500 per annum, payable quarterly, to commence on the 2d of August, 1832, you having been employed since that time in the necessary arrangements of the instruments and other preparatory works. It is to be understood, however, that you will still continue your services in the construction of weights and measures for the custom-houses as far as may be compatible with your duties in the Coast Survey, without any other compensation than what is allowed for the Coast Survey.

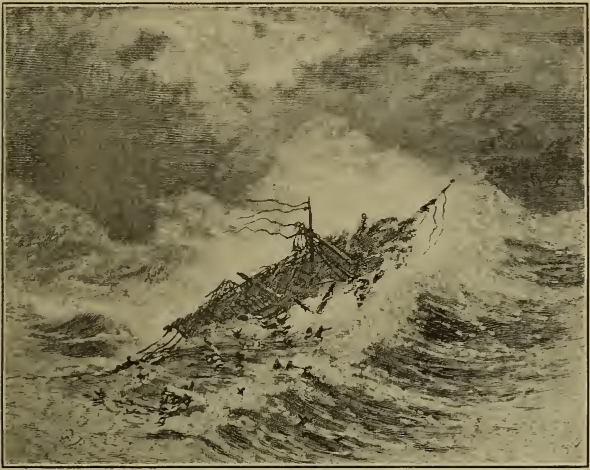

FIG. 39.—COAST SURVEY BRIG "WASHINGTON" IN HURRICANE, SEPTEMBER 8, 1846

Lieutenant George M. Bache and 10 seamen lost on this occasion

In all other respects than those indicated by this letter, the terms and nature of your employment will be the same as were fixed by the letter addressed to you by this department on the 3d of August, 1816.

The plan of operations and methods formerly adopted by you in the Coast Survey having been approved of, you will recommence and continue the work in conformity with them, including such modifications as are suggested in your report of the 6th instant.

I am, respectfully, your obedient servant,

LOUIS M'LANE,
Secretary of the Treasury.

F. R. HASSLER, Esq.

FIG. 40.—COAST SURVEY SCHOONER "EXPERIMENT," 1835–1839

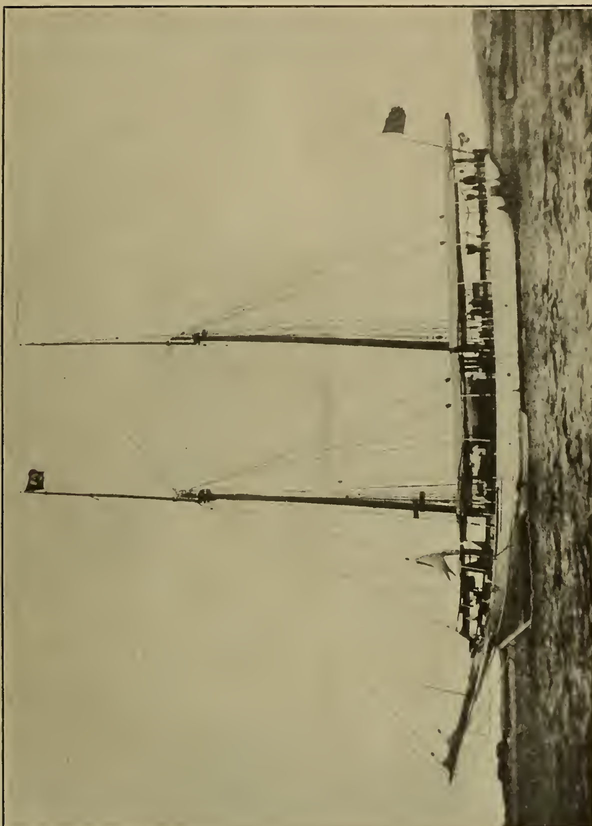

FIG. 41.—COAST AND GEODETIC SURVEY SCHOONER "MATCHLESS," BUILT IN 1859 AND STILL IN ACTIVE SERVICE

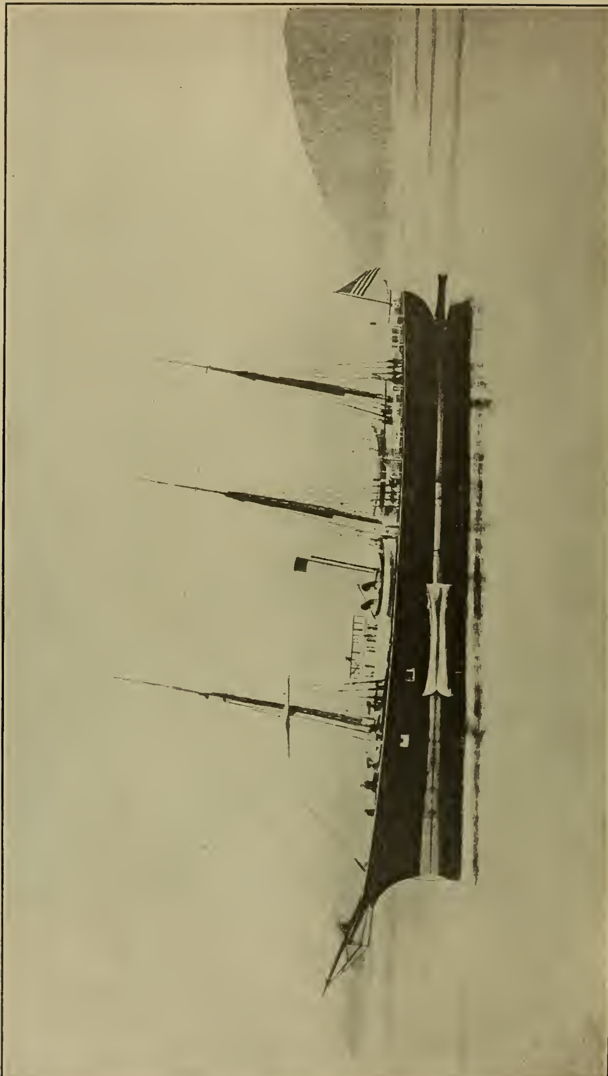

FIG. 42.—COAST AND GEODETIC SURVEY STEAMER "HASSLER," 1876-1895

FIG. 43.—COAST AND GEODETIC SURVEY STEAMER "BLAKE," 1874–1905

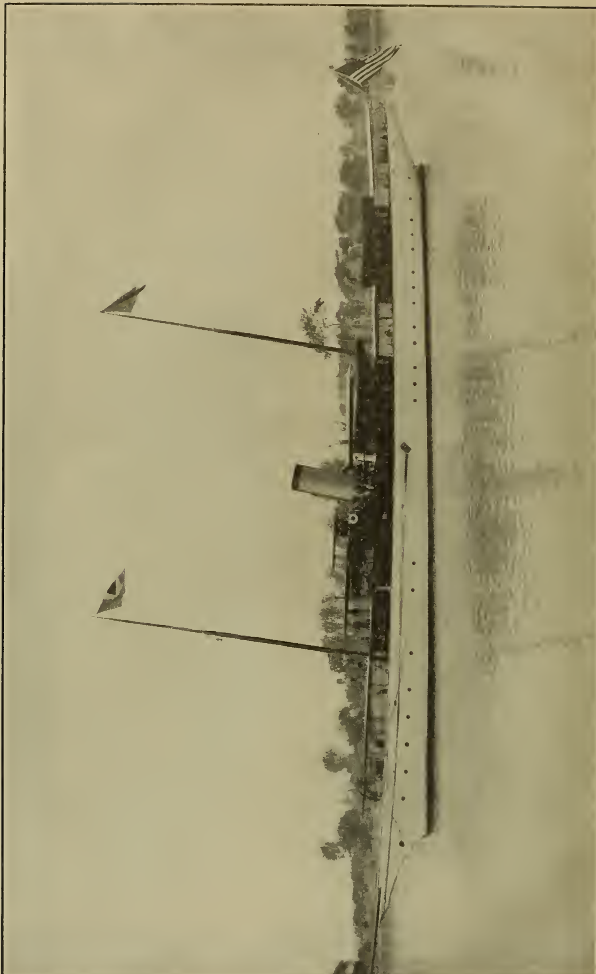

FIG. 44.—COAST AND GEODETIC SURVEY STEAMER "ISIS," 1915

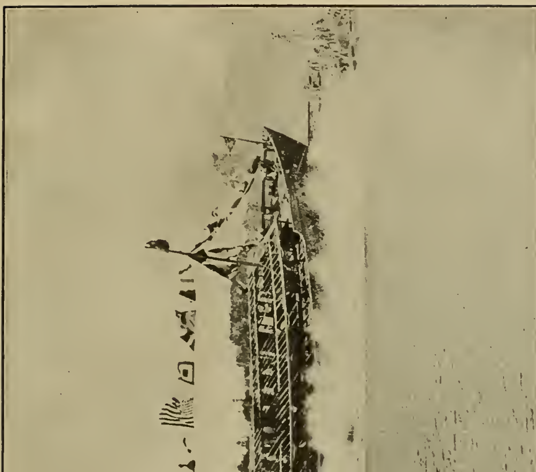

FIG. 45.—LAUNCHING THE CENTENNIAL SURVEY SHIP "SURVEYOR" JULY 22, 1916

HISTORICAL DATA FROM LIST IN "PRINCIPAL DOCUMENTS RELATING TO SURVEY OF COAST OF THE UNITED STATES," EDITED AND PUBLISHED BY F. R. HASSLER, IN 1834

PRINCIPAL DATES OF THE SURVEY OF THE COAST

As it may be of some interest, in future times, to refer to the transactions relating to this work, it may be proper to add to these papers the notice, by order of their dates of the principal documents to which it has given rise, and of the success proceeding of the work itself. This public notice, given herewith, may serve to find the documents themselves if needed.

1807

February 10th.—Act of Congress authorizing the President to cause the whole of the coast and harbors of the United States, with the adjacent shoals and soundings to be surveyed.

March 25th.—Circular letter of the Secretary of the Treasury, requesting to suggest a plan of operation for the intended work. One was addressed to me in Philadelphia.

April 2d.—My general plan of operation for the work, (in French.)

July 21st.—Letter of Robert Patterson, Esq., Director of the Mint in Philadelphia, informing me, in West Point, of the President's confidence in the plan I suggested; but that the situation of external relations occasioned to postpone the execution, requesting me to communicate upon the necessary instruments, in a preparatory manner.

August 10th.—I communicated to Mr. Patterson my ideas upon the necessary instruments, the different manners of procuring them of good quality, and proposed to make plans for same.

September 2d.—Letter of Mr. Patterson to me, proposing me, if I would go to London to direct the construction of the instruments there, as no man of this country was just there, acquainted with this subject, and requesting an estimate of the amount of the instruments.

September 12th.—My answer to Mr. Patterson, containing the desired estimate, and announcing my willingness to undertake the mission if desired.

1811

Here the whole rested until March, 1811, when a friend of mine informed me, that Mr. Gallatin, Secretary of the Treasury, wished to know if I would yet undertake the mission to London, for the instruments; upon which, I mentioned him my willingness for it.

April 16th.—Mr. Gallatin, by the direction of the President, proposed the mission.

May 14th to 25th.—Definitive agreement for the mission; the letter arriving while I was in a bilious fever; with the first recovery I worked at the plans for the instruments—base apparatus, &c.—making drawings of them in full size, upon eleven plates, (I showed after to Mr. Gallatin and Mr. Patterson, and took with me to London, for the instruction of the artists).

July 27th.—Left Schenectady for my mission, and my first compensation began.

August 9th, 10th, 11th.—Met Mr. Gallatin in Philadelphia, and, upon his direction, agreed with Robert Patterson, Esq., about the instruments, &c.

August 25th.—Mr. Gallatin approved of the instruments proposed, and gave me my instructions, passport, and a letter of credit upon Messrs. Baring, Brothers & Co., in London, for the payment of the instruments.

August 29th.—Embarked on board the Armata for Liverpool.

November 2d to 14th.—I made report to the Treasury Department of my arrival in London, and my visits to the artists· the necessity of applying to Mr. Troughton alone for the main instruments; and the probable necessity of a longer stay than contemplated, on account of his being yet occupied with the mural circle of Greenwich; entering into various other details.

1812

January 8th.—My report to the Treasury Department, giving a detailed account of the manner in which I had distributed the work among the artists.

March 22d.—My further report upon the proceedings with the artists; first account upon money received from Messrs. Baring, Brothers & Co.; and request for directions in the case of a change of the political connexions between the United States and Great Britain.

June 27th.—Letter from the Treasury Department, directing me to remain in London until the completion of the object of my mission, political changes notwithstanding.

August 1st.—Letter to Robert Patterson, Esq., Philadelphia, upon the subject of my mission.

November 25th.—Letter from the Treasury Department, prolonging my stay in London, and answering the questions contained in the letter to Mr. Patterson.

1814

January 3d.—I made a detailed report to the Treasury Department, upon the state of each object of my mission, and sent in my sixth account upon the money.

1815

March 10th.—Compared with Mr. Troughton the French Metres with the Standard Scale he had made for me.

June 24th.—I delivered to Mr. Gallatin, in London, a general account, upon the employment of the funds of the credit given to me; showing by estimate also, what was needed to complete the full payment of the instruments.

August 4th.—Date of my last report from London upon my mission; my last account upon the money of the credit upon Messrs. Baring, Brothers & Co., and duplicates of all the vouchers belonging to it, which I delivered the day after to his excellency Mr. Adams, Ambassador of the United States in London, to be forwarded to the Treasury Department. During all the time, I kept a regular journal upon all my proceedings, in which I inserted every detail, &c.

August 8th.—I left London for Gravesend, to embark on board the ship Susan for Philadelphia.

October 16th.—I informed Mr. Dallas, Secretary of the Treasury, of my safe arrival in the Delaware Bay, with the instruments.

October 31st till December 14th.—I deposited all the instruments and books of the Government's collection, at the University of Philadelphia, under the care of Robert Patterson, Esq., unpacked them, and delivered them in form, as completion of my mission.

December 31st.—I arrived in Washington for the first time.

1816

January 5th.—I delivered to the Secretary of the Treasury the plan for putting the Survey of the Coast in operation, according to the desire of the President.

January 11th.—I delivered to the Secretary of the Treasury the sketch of my accounts, both for compensation and balance on the instruments, and other papers relating to my mission.

January 20th.—Mr. Dallas communicated to me the President's approbation of my plan, handed in the 5th instant, upon which would be acted when the appropriation, then before Congress, would pass; until that time also, the settlement of my accounting concerns was referred.

April 4th.—Message of the President, and report of Mr. Dallas, upon the progress for the arrangements for the Survey of the Coast, stating my return from my mission, and that the instruments had given satisfaction.

May 2d.—Notice of the Secretary of the Treasury, of the passing of the appropriation in Congress, and request to concert with Mr. Patterson upon the measures to be taken to activate the work.

July 21st.—I set off for Philadelphia, where I had a conversation with the Secretary of the Treasury, upon various details of arrangement; and asked if it was desired that I should begin in a certain place; which he saying to be indifferent, I proposed to begin near New York, as being most favorable in principle, which he approved of.

July 27th.—I arrived at Mount Holly, near Burlington, New Jersey, with the necessary instruments for reconnoitering, and requested Major T. T. Abert, of the United States Topographical Engineers, who had been appointed by the Secretary of War as officer to assist me in the work, to come with me; but not having any funds, for the expenditures to be made on public account, he did not come with me. I proceeded therefore alone, and went to Brooklyn, requesting General Swift to send some young officers or cadets with me, for the continuance of my turn.

August 6th.—I left Brooklyn with three cadets, then there in vacancy from the Military Academy, and proceeded on Long Island, to view Hempstead plains and the hills till Setauket; then passing the Sound, visited the opposite hills of Connecticut, till again to New York.

September 17th.—We reconnoitered on Long Branch, Navesink, and the adjoining country till to Monmouth Court House, expecting to find a locality for a base line on Long Branch, as Hempstead plains had been found unfavorable.

September 28th.—Left New Brunswick with Major Abert, and continued the reconnoitering from the Beaver dam in Monmouth county, and all the Jersey shore south till Cape May, and up on both sides of the Delaware till Philiadelphia.

October 16th.—At Philadelphia, had a conversation with Mr. Dallas, and directed the construction of the boxes for the base apparatus. Then returned to Newark, to combine the results of the reconnoitering, which giving some probability for a suitable base on Long Branch, I requested Major Abert to meet me with the wagon and horses at Mount Pleasant, and General Swift to send there two soldiers for the manual assistance needed.

December 18th.—I communicated to the Treasury Department the decision of the Legislature of New Jersey, to receive proposals for an accurate map of the state, and proposed certain arrangements, by which these views of the State Government could be made to concur with the Survey of the Coast, with mutual advantage, for economy, acceleration, &c., in which I had reason to believe the State Government disposed to enter, and make a law, so much wanted for the protection of my work and signals, permission to clear views, &c., presenting general views upon this subject, and requesting instructions upon it. I pressed, also, the building of an observatory, &c. To this I added a separate letter, requesting again funds to be given into the hands of Major Abert.