Homer P. Ritter

REPORT OF THE SUPERINTENDENT

OF THE

U. S. COAST AND GEODETIC SURVEY

SHOWING

THE PROGRESS OF THE WORK

DURING THE

FISCAL YEAR ENDING WITH

JUNE, 1888.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1889.

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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LETTER

FROM

THE SECRETARY OF THE TREASURY,

TRANSMITTING

The annual report of the Superintendent of the U. S. Coast and Geodetic Survey.

DECEMBER 11, 1888.—Referred to the Committee on Appropriations and ordered to be printed.

TREASURY DEPARTMENT, *December* 10, 1888.

SIR: In compliance with the requirements of section 4690, Revised Statutes, I have the honor to transmit herewith, for the information of Congress, a report addressed to this Department by F. M. Thorn, Superintendent of the Coast and Geodetic Survey, showing the progress made in that work during the fiscal year ended June 30, 1888, and accompanied by charts illlustrating the general advance in the operations of the Survey up to that date.

Respectfully, yours,

C. S. FAIRCHILD,
Secretary.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

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ERRATA.

Coast and Geodetic Survey Report for 1887.

Page 22, twenty-fourth line from top, for *Cutter* put Cutler.
Pape 81, nineteenth line from bottom, for *ten feet and five-tenths* put 105 feet.

ERRATA.

Coast and Geodetic Survey Report for 1888.

Page 43, tenth line from bottom, for *tracks* put *tracts*.

Page 61, fourteenth line from top, for *Walker* read *Welker*.

Page 81, fifteenth line from top, for *Mossman* put *Mosman*.

Page 91, tenth line from top, for *Eicholtz* put *Eichholtz*.

Page 91, sixteenth line from top, for *O. H.* French put *H. O.* French.

Page 92, thirteenth line from top, for *Mills* read *Wills;* and on page 146, eighteenth line from bottom, make same correction.

Page 105, eighth line from top of table, for *bench* put *beach*.

Page 105, twenty-first and twenty-ninth lines from top of table, dele *including two stations re-occupied.*

Page 105, same lines in column of figures, change **6** to **3**, and change **143** to **140**, change **3** to **0**, and change **22** to **19**.

Page 113, eighth line from top, after *eighteen hundred* insert *and fifty*.

Page 114, seventh line from top, for *Gerhard* put *Gerhards*.

Page 119, nineteenth line from bottom, for *oue* put *one*.

Page 120, twenty-second line from top, for *Crawford* put *Craufurd*.

Page 123, seventh line from top, for **1** in right-hand column put **4**.

Page 123, tenth line from top, after **1,3** in right-hand column insert **4**.

Page 123, eighteenth line from bottom, in column of scales, for **1-80000** put **1-40000**.

Page 124, seventh line from top, in column of titles, for *Cove* read *Core*.

Page 127, No. 425, eleventh line from bottom, for *Sommers* put *Sommer*.

Pages 134 and 135—wherever the phrases, *read maregrams, reading maregrams,* etc.—occur, substitute *tabulated tidal curves,* or *tabulating tidal curves.*

Page 135, thirteenth line from top, for *Glova* put *Glora*, and on page 157, eleventh line from bottom, make same correction.

Page 135, twenty-sixth and twenty-seventh lines from top, dele *increasing the establishment at Astoria by* 23^{m}.

Page 142, eighteenth line from top of list, dele *Ratz Harbor* before *Coffman's Cove*.

Page 142, twenty seventh line from top of list, after *longitude* 89° 35 insert *to Barataria Bay*.

Page 153, twenty-fifth line from top, for *Stephan's Sound and Frederick Passage* put *Stephens Passage and Frederick Sound*.

Page 160, twenty-third line from top, for *Suison* put *Suisun*.

Page 161, thirtieth line from bottom, for *Harbor of Beaufort, Sachem's Head* put *Harbors of Branford, Sachem's Head, etc.*

Page 161, twenty-seventh line from bottom, for *Davenport Island* put *New Rochelle*.

Page 161, twelfth line from bottom, insert **609** in column of chart numbers and dele *Bay*.

Page 161, second line from bottom, for 1-20000 put 1-200000.

Page 161, last line, for 1-300000 put 1-3000000.

Page 164, under heading "Lieutenants Junior Grade," for *Dewitt* put *De Witt*.

Page 165, under heading "Atlantic and Gulf Coasts," dele *Passed* before Assistant Engineer Samuel H. Leonard, jr.

REPORT.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, D. C., December 10, 1888.

SIR: In accordance with law and with the regulations of the Treasury Department, I have the honor to submit herewith a report of the progress and state of the work of the Coast and Geodetic Survey during the fiscal year which ended June 30, 1888, with a view to the same being laid before the President and Congress.

The report is accompanied by a map of general progress, upon which is shown graphically the advance made in the several operations of the survey up to the close of the fiscal year. As the scale of this map does not admit of showing the extended coast line of Alaska, a separate map exhibits the progress of the work in that Territory.

During the past year the work has made most satisfactory progress in every direction of its development as a geodetic survey, intended for purposes of commerce and defense upon the coasts of the United States, and intended also to establish accurate bases for State surveys by chains of triangulation so connected as to form "a frame work into which all local surveys must rigorously fit."

To complete the work upon the Atlantic and Gulf coasts there are still needed surveys and investigations, which, though less urgently demanded than have been others of more immediate bearing upon the interests of commerce and navigation, are yet essential to a complete survey of the coasts of the United States.

These are chiefly the finishing of the survey of the coast of Maine to the Northeastern Boundary; the continuation of the investigations in physical hydrography relating to harbors and bars, with special reference to the study of shoal formations, the laws governing the action of currents, and the movement of ice and its effect upon navigation; the continuation of off-shore soundings in the North Atlantic, and of current and temperature observations in the Gulf Stream; the continuation of the survey of the western coast of Florida between Cape Sable and Cape Romano; the surveys of Pensacola and Perdido Bays and their tributaries, and their connection with the main triangulation; the survey of Lake Pontchartrain and of the coast of Louisiana from Barataria Bay to Sabine Pass, with such off-shore hydrography as may be required; the connection of points on the Gulf of Mexico by lines of geodetic leveling with the transcontinental line of leveling of precision, and the survey of the Rio Grande River to the head of ship navigation.

From time to time there will be needed also such resurveys as may be demanded to determine local changes in important harbors or highways of commerce and to keep the charts and coast pilots corrected to date.

For geodetic purposes there will be needed a line of primary triangulation which shall connect the triangulations upon the coasts of North or South Carolina with the primary triangulation along the Blue Ridge, a line which shall complete the connection of the triangulations on the east and west coasts of Florida by a series of triangles between Fernandina and Cedar Keys, and a line which shall finish the connection between the main triangulation in Northern Georgia and Alabama and that of the Gulf of Mexico. The measurement just named is now well advanced; its completion will carry an oblique arc of the meridian from the northeastern boundary to the Gulf, and will supply data of special value in determining the elements upon which depend our knowledge of the size and figure of the earth.

The sketch of general progress shows the belt of triangulation upon the results of which the measurement of this arc depends; it shows also a belt, now advancing towards completion, between the head of Chesapeake Bay and Lake Ontario, by which the Pamplico–Chesapeake–Lake Ontario arc of the meridian will be carried four degrees farther north.

It will be observed by an inspection of the map that the purposes of geodesy will be subserved, and the more immediately practical results required in the State surveys will be secured, as progress is made in the lines of transcontinental triangulation, projected to connect the work on the Atlantic and Pacific coasts. Upon the completion of these lines, two arcs of the parallel will have been measured, one between Cape May and Point Arena, the other between Cape Hatteras and San Luis Obispo. Incidentally there will have been determined geographical positions and elevations above sea level in twenty-one States and four Territories; the location of the principal meridians of the General Land Office will have been checked by precise measurements, and means furnished for accurate determinations of State boundaries.

The northernmost of these lines, that on or near the thirty-ninth parallel, has now so far advanced that its early completion is looked forward to. When the measurement of this arc of the parallel of forty-nine degrees—the longest ever obtained—can be combined with the measurement of a central arc of the meridian, carried along or near the ninety-ninth degree from the Rio Grande to the northern boundary, geodesy will have secured the data desired to determine the elements of the spheroid best adapted for discussing the final results of the geodetic survey of the United States.

Upon the coasts of California, Oregon, and Washington Territory, the survey has so far advanced that charts of all the more important harbors and anchorages have been published, and by these, and by the views and descriptions of the Coast Pilots, their approaches and entrances are well known to navigators. Much work remains to be done in the triangulation and topography of the less important stretches of coast, and much of the off-shore hydrography and observation of ocean currents.

The primary triangulation near the coast in California, Oregon, and Washington Territory should be completed and connected with the transcontinental triangulation, and such primary bases of verification measured as may be necessary. The survey of the Columbia River should be carried from the mouth of the Willamette to the Cascades, and the transcontinental line of levels of precision should be pushed eastward from San Francisco.

Such determinations of gravity and the magnetic elements should be made upon the Atlantic and Pacific coasts and in the interior as the progress of the survey requires.

While changes from natural causes are perhaps less frequent upon the Pacific coast than upon the Atlantic, those from artificial causes occur quite as often. Resurveys have lately been demanded of two of the most important harbors, San Francisco and San Diego.

An arc of the meridian of the Pacific is now in course of development on or near the one hundred and twenty-third degree of longitude by the triangulation partly completed between Monterey Bay and the Gulf of Georgia.

In Alaska, the more detailed surveys have been confined to those sections of the coast the resources of which have had during late years such rapid development. Immediately upon the acquisition of the territory, a geographical reconnaissance was carried from Sitka to Unalashka Island, and detached surveys have since been made as far west as the Pribiloff Islands in Bering Sea. Recent estimates give for the coast line of Alaska from the Archipelago Alexander to the Chichagoff Islands, a length of seven thousand eight hundred and forty miles, and from the Chichagoff shore of Icy Strait westward to Point Barrow, Wrangell Island, and Herald Island, a length of eighteen thousand five hundred and twenty-four miles, making in all twenty-six thousand three hundred and sixty-four miles, which is but three thousand six hundred and forty miles less, according to the same estimates, than the entire Pacific coast line of the United States. The map shows that good progress has been made in surveys and explorations in the Alexander Archipelago, between Dixon Entrance and Cross Sound, and that the coast line has been delineated from near Cape Spencer to Icy Bay. Other localities are indicated where detached surveys have been made.

By recent Congressional enactment,* a preliminary survey of the frontier line between Alaska and British Columbia in accordance with plans or projects approved by the Secretary of State has been placed in charge of this Bureau. Such a preliminary survey, involving the determination of a number of points in geographical position and their complete marking by permanent monuments, will have to be carried from Cape Muzon through the Portland Canal to the fifty-sixth degree of north latitude, thence northwestwardly, following as nearly as may be practicable the general trend of the coast, at a distance of about thirty-five miles from it, to the one hundred and forty-first degree of west longitude, and thence due north to the Arctic Ocean, a total distance of about fourteen hundred miles.

Part I of this report gives a summary of the leading operations of the Survey during the year, followed by general statements of progress in field and office work, by notices of discoveries and developments and of special scientific work, by notices of bulletins, the publication of which was begun during the year, and by an explanation of estimates and estimates in detail for 1889–'90.

Part II begins with an introductory statement, relating mainly to the offices of the Assistant in charge and the Hydrographic Inspector; it then presents abstracts of the reports of chiefs of field parties arranged in a geographical order, concluding with a notice of special operations, a summary statement of office operations, including those of the sub-offices at Philadelphia and San Francisco, and a final statement by the Superintendent.

Part III contains the appendices. Those from Nos. 1 to 5 inclusive show the work of the Survey by tabular statements and the reports of the Assistant in charge of the Office and the Hydrographic Inspector; the remaining appendices embody scientific papers presenting methods or results of the work in forms desirable for publication.

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* Sundry Civil Expenses Act, 1888–'89, page 12.

PART I.

During the past fiscal year the scale upon which the work has been prosecuted has been fully commensurate with the means afforded by Congress.

Surveys involving triangulation and topography, astronomical and magnetic observations, determinations of elevations by lines of geodetic leveling, and observations for the value of gravity were carried on within the limits or upon the coasts of twenty-one States, three Territories, and in the District of Columbia. Hydrographic surveys, including observations of tides and currents, off-shore and inshore soundings, observations of ice movement, and researches in physical hydrography relating to harbors and bars, were prosecuted in the waters or off the coasts of fifteen States and two Territories.

The necessity for connecting the extended series of triangulations of the Survey with other works of similar character carried on by independent organizations and methods was not lost sight of. Upon the northeastern coast of Maine, the connection of the island of Grand Manan with the primary triangulation, and the advance towards completion of the triangulation of the St. Croix River will ultimately join the Coast and Geodetic Survey work with the surveys of the Dominion of Canada and with the Northeastern Boundary Survey, which will thus afford a check to the coast triangulation. In Wisconsin, the geodetic operations in progress have effected another junction with the work of the U. S. Lake Survey, one having been previously made by the triangulation crossing the State of New York. In Indiana and Illinois, the transcontinental triangulation, advancing eastward near the thirty-ninth parallel, has been connected with the second and third principal meridians of the General Land Office. The accurate determinations of geographical positions made in the progress of the work, according to the most approved methods of modern geodesy, whether on the coast or in the interior, continue to be freely communicated to the Geological Survey, and serve to check the approximate positions obtained in the course of its preliminary triangulations.

Among the more important field operations of the year may be mentioned the combined observations of precise leveling, and of the direction and velocity of currents for ascertaining the successive tidal levels in New York Harbor and the relation of the under-run of the Hudson River to the New York Bar; the continuation of the study of ice formation and movement in Delaware River and Bay; the prosecution of the explorations of the Gulf Stream; the advance towards completion of the triangulation needed to extend the oblique arc of the meridian from Calais, Maine, to Mobile, Alabama, and to unite the triangulations of the Atlantic and Gulf coasts; the extension of the line of transcontinental leveling from the Mississippi River to Little Rock, Arkansas; shore-line resurveys of important harbors on the Pacific coast; determinations of gravity at San Francisco and Mount Hamilton, California, and at Washington, D. C., in connection with similar determinations made on the Hawaiian Islands, and progress made in the surveys of harbors and channels in southeastern Alaska.

The special triangulation asked for by the Commissioners of the topographical survey of the State of Massachusetts was continued; geodetic work in co-operation with State geological or topographical surveys was carried on in the States of Pennsylvania, New Jersey, Tennessee, Arkansas, Wisconsin, and Minnesota; additional determinations of geographical positions were made by the longitude parties on the Pacific slope.

By direction of the Secretary of the Treasury and at the request of the Secretary of State, a special examination and survey was made of the boundary line between the United States and Canada in the vicinity of Burnt Island, Lake Huron.

In co-operation with the District Commissioners, unusually rapid progress was made in the detailed topographical survey of the District of Columbia.

The geodetic work on the Hawaiian Islands, already referred to, was done by an officer of the Survey, detailed for that purpose by direction of the Secretary of the Treasury and granted leave without pay during the operations, which were undertaken at the request and expense of the Hawaiian Government.

GENERAL STATEMENT OF PROGRESS.

I.—FIELD-WORK.

ATLANTIC COAST.—During the fiscal year ended June 30, 1888, the following operations were included in the work of the Survey upon the coasts and within the borders of the New England States:

Triangulation of the St. Croix River to connect with the Northeastern Boundary Survey, continued; topographical surveys on the right bank of the St. Croix River and Cobscook Bay; hydrographic surveys in the vicinity of Eastport, Maine, in St. Croix River, and Cobscook Bay; triangulation upon Grand Manan and vicinity; inspection of topography upon the eastern coast of Maine; hydrographic examinations for the Coast Pilot upon the coast of Maine, between Eastport and Portland; completion of the series of tidal records from the automatic tide-gauge at Pulpit Cove, North Haven Island, Penobscot Bay, Maine; magnetic stations occupied in Maine and Massachusetts; continuation of the determinations of town boundary lines in Massachusetts; physical hydrographic surveys continued on the coast of Massachusetts between Nausett and Chatham; triangulation, shore-line, and hydrographic resurveys of Nantucket and Vineyard Sounds; off-shore soundings from Phelps Bank to Montauk Point; hydrographic resurveys between Cuttyhunk and Point Judith; observations of currents in the vicinity of No Man's Land and Block Island, and hydrographic examinations for the Coast Pilot in Vineyard and Nantucket Sounds and in Buzzard's Bay.

Upon the coasts and within the limits of New York, New Jersey, Pennsylvania, and Delaware, field operations included shore-line resurveys on the north coast of Long Island, in Nyack Bay and Great and Little Peconic Bays; triangulation and shore-line topography at the east end of Long Island and along the south shore to Great Point Bay; topographic resurvey of the south coast of Long Island from Babylon to Woodsburgh, and soundings in Fire Island Inlet; observations of currents in the approaches to New York Harbor, and physical hydrographic surveys in that harbor and approaches; connection of the tide-gauges and tidal bench-marks on and near New York Harbor by lines of leveling of precision; continuation of the series of tidal records from the automatic tide-gauge at Sandy Hook, New Jersey; geodetic operations continued in southwestern Pennsylvania and in southern New Jersey, and observations of ice formation and movement in Delaware River and Bay continued.

Within the District of Columbia and the State of West Virginia and upon the coasts and within the boundaries of the States of Maryland, Virginia, North and South Carolina, and Georgia, field-work included special observations for determinations of gravity at the Smithsonian Institution, Washington; annual determinations at Washington of the magnetic elements; continuation of the detailed topographical survey of the District of Columbia; hydrographic resurveys of Chincoteague Bay, Inlet, and Bar, coast of Virginia; triangulation and topography on the coast of Virginia at Cape Charles and vicinity completed, and hydrographic resurveys in that vicinity begun; special hydrography for the State of North Carolina continued in the sounds of that State; connection of old and new triangulations on the coast of North Carolina, and hydrographic examinations at the entrance to St. Simon's Sound, Georgia.

Upon the east and west coasts of Florida, in the approaches to these coasts, in the Windward Island passages, and upon the coasts and within the limits of the Gulf States, the following-named operations were in progress or completed: Explorations of the Gulf Stream continued by observations of currents in the Windward Island passages and in the course of the Stream through the Caribbean Sea; hydrographic surveys on the west coast of Florida between Cape Sable and Key West; topographic survey from Pavilion Key to Cape Romano, west coast of Florida; reconnaissance and triangulation continued for connecting the primary triangulation in northern Alabama with that of the Gulf; survey of the Mobile River completed from Spanish River to the junction of the Alabama and Tombigbee Rivers; reconnaissance, triangulation, observations for latitude and azimuth, topography and hydrography on the coast of Louisiana, between Last Island and Côte Blanche Bay; topographic survey on that coast between Vermillion Bay and Calcasieu Pass; hydrographic survey of Vermillion Bay and of the Louisiana coast from Ship Shoal towards the Mermentau River.

PACIFIC COAST.—Upon the coasts and within the boundaries of the States of California and Oregon, of Washington Territory and of Alaska, field operations in progress or completed, included the completion of the tertiary triangulation and part of the topography between San Diego Bay and San Mateo, California; the completion of the examinations for physical changes and the shore-line resurveys in San Diego Bay and vicinity; special examinations of the physical hydrography of San Juan Capistrano, Newport Bay, San Pedro Bay, and La Ballona, California; continuation of the series of magnetic observations with the self-registering magnetic apparatus at Los Angeles, California, and examination of the site for a primary base-line near Los Angeles; tertiary triangulation and topography from San Carpoforo Creek westward to Point San Martin; views of the Pacific Coast Pilot obtained from Piedras Blancas to Point Pinos; continuation of the main triangulation of the coast of California, and observations for latitude in connection with it at Lafayette Park Station in San Francisco; magnetic observations at the station Presidio, California; tidal observations continued at the automatic tidal station Saucelito, San Francisco Bay; special determinations of gravity at San Francisco and at Mount Hamilton, California, in connection with similar determinations on the Hawaiian Islands; observations for longitude at the Lafayette Park station, San Francisco; resurvey of the shore lines in Suisun Bay and adjoining waters; hydrographic examinations in Eel River entrance, California; topographical reconnaissance and surveys with selection of sites for light-houses on the coast of Oregon from Cape Sebastian to Cape Orford, from the Umpquah River to the Yaquina River, and from the Yaquina River to Tillamook Bay; longitude observations and determinations of latitude and the magnetic elements at Portland, Oregon, and at Walla Walla, Washington Territory, also at Yaquina, Oregon, and Seattle, Washington Territory; topographical resurvey of the water front at Astoria, Oregon, and recovery and remarking of tidal bench-marks; hydrographic survey of Shoalwater Bay and approaches, Washington Territory, and off-shore soundings between that bay and Cape Flattery; triangulation, topography and hydrography in Saratoga Passage and adjoining waters, Washington Territory; hydrographic surveys in Rosario Strait; triangulation and topography in Bellingham Bay and vicinity, and connection of the triangulations in that bay and Rosario strait; triangulation begun in the Gulf of Georgia; hydrographic surveys continued and examinations for the Pacific Coast Pilot made on the coast of Alaska and the Aleutian Islands, and series of tidal records with automatic tide-gauge continued at St. Paul, Kadiak Island, Alaska.

INTERIOR STATES.—In the States between the Atlantic and Pacific coasts, field-work included the extension to the westward of the transcontinental triangulation in Ohio and Kentucky, its extension to the eastward in Indiana, and a reconnaissance to develop a scheme for the connection of the triangulation in those States; the continuation of geodetic operations in aid of State surveys in the States of Tennessee, Arkansas, Wisconsin, and Minnesota; examination and survey of the boundary line between the United States and Canada in the State of Michigan; topographical survey made of the site of the American Bottom base-line in Illinois; lines of geodetic leveling carried from the Mississippi River to Little Rock, Arkansas, and in Missouri from the town of New Haven to near Osage City; extension to the westward in the State of Kansas of the transcontinental triangulation near the thirty-ninth parallel; longitude determinations at Salt Lake City, Utah, and extension to the eastward of the transcontinental triangulation in the Territory of Utah.

SPECIAL OPERATIONS during the year included the determination for the Department of State, by direction of the Secretary of the Treasury, of the boundary line between the United

States and Canada at Burnt Island, Lake Huron, and the completion of the determinations of latitude and gravity upon the Hawaiian Islands, made by an officer of the Survey at the request and sole expense of the Hawaiian Government, with the approval of the Secretary of the Treasury

II.—OFFICE-WORK.

Special attention was given during the year in the office of the Survey to the prompt publication of results of immediate value to the interests of commerce and navigation. Reference to the notices to mariners issued from time to time is made under the following heading. The free distribution of upwards of thirty-five thousand copies of these notices shows that care was taken to disseminate widely information of discoveries or developments made in the progress of the work.

Tide tables, predicting for the year 1889 the times and heights of high and low water at all the principal ports on the Atlantic and Pacific coasts, were published. From the times and heights at the chief ports, those for minor ports and harbors can be deduced by tidal differences and ratios. A new Catalogue of Charts was published, with index maps, showing the limits of the charts; also a new volume of the Atlantic Local Coast Pilot, covering the coast from Tybee Roads to Jupiter Inlet. A third edition of subdivisions 6 and 7 (in one volume), including the coast from Cape Ann to Monomoy, was in press at the close of the year, and a new Coast Pilot volume, covering the coast from Point Judith to the East River, was practically completed at that date.

The drawings of sixteen new charts were finished, and those of one hundred and twelve charts were in hand to receive additions and corrections for the preparation of new editions and for completion. Twelve new charts were engraved and the engravings of new editions of ten charts were finished. Twelve new charts were published from engraved plates and eleven from photolithographs.* The total number of charts printed during the year was forty-four thousand and ninety-three. Of this number twenty-five thousand two hundred and seventy-three were sent to sale agents, two thousand four hundred and eighty-three supplied for the use of Congress, and eleven thousand six hundred and eight for the several Executive Departments.

Distribution was made as heretofore of the Annual Reports of the Survey and the appendices to the same, of which extra editions were printed to meet the usual demands from educational and scientific institutions and the public.

The annual report of the Assistant in charge of the Office and Topography, which appears as Appendix No. 4 to this volume, gives full details of the progress made in the work of the office during the year. A summary of this report will be found towards the close of Part II.

III.—DISCOVERIES AND DEVELOPMENTS.

Discoveries and developments made in the progress of the survey which have a close bearing upon the interests of navigation and commerce are published at the earliest date practicable in the form of Notices to Mariners.

Since the beginning of the fiscal year a series of these notices has been published monthly in pursuance of a suggestion made by the Hydrographic Inspector. These monthly notices give all important corrections made on the charts during the month preceding their issue, including all changes in buoys, beacons, or lights, and references to any special notices that may have appeared; also lists of charts suspended or condemned and new charts issued. Special notices, giving information of immediate value to mariners, are published as occasion may demand.

An abstract by number, date, and title of the fifteen notices published during the year is here given. Thirty-five thousand five hundred copies were printed for free distribution:

No. 89, 1887, July 30. Chart corrections during the month of July, 1887.
No. 90, 1887, August 31. Chart corrections during the month of August, 1887.
No. 91, 1887, September 30. Chart corrections during the month of September, 1887.

* In addition to the eleven charts published by photolithography, and already received in the chart-room, there were on June 30, 1888, in the hands of the photolithographer, complete for publication, the drawings of twenty charts, the work upon which should be credited to the fiscal year 1887–'88.

No. 92, 1887, October 31. Chart corrections during the month of October, 1887.
No. 93, 1887, November 8. Dangerous rock in Vineyard Sound, Massachusetts.
No. 94, 1887, November 22. Gulf Stream currents.
No. 95, 1887, November 30. Chart corrections during the month of November, 1887.
No. 96, 1887, December 31. Chart corrections during the month of December, 1887.
No. 97, 1888, January 9. Coast currents, approaching Sandy Hook.
No. 98, 1888, January 31. Chart corrections during the month of January, 1888.
No. 99, 1888, February 29. Chart corrections during the month of February, 1888.
No. 100, 1888, March 31. Chart corrections during the month of March, 1888.
No. 101, 1888, April 30. Chart corrections during the month of April, 1888.
No. 102, 1888, May 31. Chart corrections during the month of May, 1888.
No. 103, 1888, June 30. Chart corrections during the month of June, 1888.

Among the references to new publications in No. 103 is one to a series of papers under the title of Bulletins, the first number of which had been recently published. Further reference to the bulletins appears under the next heading.

IV.—BULLETINS.

In May, 1888, in pursuance of a suggestion made by the Hydrographic Inspector and approved by the Superintendent, the publication of a series of papers under the designation of Bulletins was decided upon. Their purpose is stated in the following explanatory note, which accompanies each bulletin:

> Papers published by the Survey under this designation will appear from time to time as material for them accumulates. They are intended to give early announcement of work accomplished or information of importance obtained, and will in many cases anticipate the usual means of publication afforded by the annual reports. The pages will be numbered consecutively, and will be indexed when their number demands it, thus augmenting their value for preservation and reference.

Before the close of the fiscal year the manuscripts of five bulletins had been submitted for publication, approved and revised for the printer. Two of these were published; No. 1, May 14, under title "Recent Publications;" No. 2, June 20, "Notes on Alaska from recent surveys."

V.—SPECIAL SCIENTIFIC WORK.

THE VALUE OF THE "ARCANO DEL MARE" WITH REFERENCE TO OUR KNOWLEDGE OF THE MAGNETIC DECLINATION IN THE EARLIER PART OF THE SEVENTEENTH CENTURY.

The discovery of a work apparently overlooked hitherto, giving, for an epoch near the first third of the seventeenth century, values of the magnetic declination for all regions then known to the navigator, led Assistant Schott to examine carefully with a view to ascertain the trustworthiness of its data and their bearing upon the secular variation of the magnetic needle in North America and adjacent regions.

This work, published in Florence, Italy, in 1646, under the title "Dell' Arcano del Mare," became known to the Survey through Justin Winsor's "Narrative and Critical History of North America, 1886," and by the courtesy of Mr. Winsor, in his capacity as librarian of Harvard University, a copy was temporarily placed at the disposal of the office.

In Appendix No. 6 Mr. Schott gives the results of his examinations of the declinations for North America and adjacent regions which are recorded in the Arcano, referring to the method adopted in that work for ascertaining the longitude at sea by means of the observed changes in the magnetic declination—though not a method original with this author, both Columbus in the fifteenth century and Sebastian Cabot in the sixteenth, having anticipated him in suggesting it. The second volume contains a series of charts notable for their boldness of outline and clearness of expression.

In the illustration (No. 19) which accompanies his paper, Mr. Schott has shown graphically the declinations given in the Arcano for North America at the estimated epoch, 1630, plus or minus ten years, with the agonic or isogonic lines for that epoch, and in illustration (No. 20) he shows the secular change in the position of the agonic line of the North Atlantic between 1500 and 1900, as derived from comparisons of Hansteen's and Halley's data with those of the Arcano and with modern observations.

THE SECULAR VARIATION OF THE MAGNETIC NEEDLE IN THE UNITED STATES AND AT SOME FOREIGN STATIONS (SEVENTH EDITION).

But a few words are needed to explain the necessity for the publication of a seventh edition of the paper by Assistant C. A. Schott on the Secular Variation of the Magnetic Needle in the United States and at some foreign stations. (Appendix No. 7.)

Apart from the constant and increasing demand for this paper, the additions to the material for discussion and analysis derived from observations are of so marked a character as greatly to improve many of the expressions given in the preceding editions. These additions consisted mainly in bringing to light a number of variations recorded in the Arcano del Mare (just referred to), and in the discovery of a number of records of the variation off the coast of Lower California made by a French officer in the year 1714.

There is also urgent need of the issue of the map showing lines of equal magnetic declination for the epoch 1890 in the United States. The value of this map must depend mainly on the accuracy with which the secular variation of the magnetic declination is known.

GEOGRAPHICAL POSITIONS IN THE STATE OF CONNECTICUT.

In pursuance of the plan of publishing from time to time the geographical positions determined by the Survey in each State, there are given in Appendix No. 8 the complete geodetic results of the various triangulations made by the Coast and Geodetic Survey in the State of Connecticut. (See illustration No. 28.) Similar results for the States of Massachusetts and Rhode Island were published in Appendix No. 8 to the report of 1885.

For the State of Connecticut, the latitudes, longitudes, and other geodetic data are given for eight hundred and seventeen trigonometrical points, determined between the years 1833 and 1886. All have been treated systematically and adjusted to the present standard data, geodetic and astronomical. On account of the large number of separate field parties, and the consequent interlacing of partial triangulations, the work of computation was one of great magnitude. Resurveys of large portions of the coast had to be made, being required by the physical changes during half a century, as well as by the demand for greater minuteness in the surveys of more recent years.

TIDAL LEVELS AND FLOW OF CURRENTS IN NEW YORK BAY AND HARBOR.

Data derived from extended series of tidal observations, made in 1886, and from heights of tidal bench-marks determined by lines of precise leveling in 1886 and 1887, have enabled Assistant Henry L. Marindin to show graphically the movements of the tide in filling and draining the tidal reservoirs surrounding New York City, and the flow of currents at successive periods of the tide.

Mr. Marindin's paper on this subject is published as Appendix No. 9 to this volume. The twelve diagrams which illustrate it (Nos. 29–40) give vertical cross-sections of the height of the tide above or below the line of mean sea-level at Sandy Hook (the datum line) for each lunar hour after the moon's transit, thus showing at intervals of about sixty-two minutes of civil time the elevations or depressions of the several tidal basins of the Hudson, the East River, and New York Bay as compared with Sandy Hook.

Near low water, or at 0 hour, as will appear from an inspection of these diagrams, and the tables given in the report, the level of the sea at Sandy Hook is very nearly 5 feet below the level of the water at Willets Point, East River. Near high water, or at VI hour, these conditions are reversed, the sea-level at Sandy Hook being about 5.4 feet higher than the level of the water at Willet's Point.

The results presented in this paper will contribute to the solution of many questions relating to the respective values of the bays and flats in and about New York Harbor as tidal reservoirs in maintaining the channel ways through Sandy Hook, and keeping unimpaired the approaches to the chief commercial city of the United States.

HEIGHTS FROM SPIRIT-LEVELING OF PRECISION BETWEEN MOBILE, ALABAMA, AND OKOLONA, MISSISSIPPI; BETWEEN NEW ORLEANS, LOUISIANA, AND WILKERSON'S LANDING, MISSISSIPPI, OPPOSITE ARKANSAS CITY, ARKANSAS, AND BETWEEN ARKANSAS CITY AND LITTLE ROCK, ARKANSAS.

In the year 1884 the method of running two parallel lines of geodetic leveling simultaneously, alternate sections being run in opposite directions, was found to give results which failed to furnish the complete or independent check and standard of accuracy required for this branch of the Survey; it was therefore abandoned, and for it was substituted the plan of running two independent lines, one forward, the other backward, the work being carried on as often as practicable by different observers, using different instruments.

The results of lines of leveling of precision, run from Mobile, Alabama, to Okolona, Mississippi; from New Orleans, Louisiana, to Wilkerson's Landing, opposite Arkansas City, Arkansas, and from Arkansas City (on Mississippi River) to Little Rock, Arkansas, are discussed by Assistant Schott in Appendices Nos. 10, 11, and 12, to this volume. The first named line was run in the years 1884, 1886, and 1887, the old method being employed in 1884, and the new one in 1886 and 1887. The second line referred to was run in 1879, 1880, and 1881 by officers of the Survey between New Orleans and Greenville, Mississippi, and by the Mississippi River Commission in 1880 and 1881 between Greenville and Wilkerson's Landing, opposite Arkansas City, Arkansas, on the Mississippi River. Between Arkansas City and Little Rock, Arkansas, the leveling was done in 1887 and 1888.

For all of the heights deduced in the discussion, the plane of reference adopted is the mean level of the Gulf of Mexico, as determined by tidal observations at Biloxi, Mississippi, and carried forward by the results of geodetic leveling in 1885 and 1886 between Mobile and New Orleans. (See Appendix No. 9, report for 1887.)

The primary bench-mark at St. Louis, Missouri, of the line of transcontinental geodetic leveling, near the thirty-ninth parallel, has already been connected by lines of leveling of precision with the Gulf mean level at Biloxi, Mississippi, the work having been done partly by this Survey, partly by the Mississippi River Commission, and partly by the United States Engineers. A more direct line, and a check connection through Mobile, Alabama, Meridian and Okolona, Mississippi, will be obtained as soon as one additional link in the chain can be completed—that between Okolona, Mississippi, and Cairo, Illinois.

DIFFERENTIAL METHOD OF COMPUTING APPARENT PLACES OF STARS FOR DETERMINATIONS OF LATITUDE.

In order to shorten the time and lessen the labor of computing the apparent declinations of stars observed for latitude when quite a number of stations had been occupied during the season, Mr. E. D. Preston, Assistant, made an investigation looking to the introduction of a differential method.

Upon application of this method to the reduction of star places for fourteen stations occupied during 1887, it was found much preferable to the usual logarithmic one. An account of it, with examples of the two methods for comparison, was prepared by Mr. Preston, and is published as Appendix No. 13 to this volume.

DETERMINATIONS OF LATITUDE AND GRAVITY FOR THE HAWAIIAN GOVERNMENT.

In the course of the triangulation of the Hawaiian Islands carried on under the direction of Prof. W. D. Alexander, Surveyor-General for the Hawaiian Government, certain discrepancies appeared between the astronomical and geodetic determinations of latitude, which indicated unusually large deflections of the plumb-line. It was decided therefore by the Hawaiian Government to ask the co-operation of the United States in establishing a number of latitude stations upon the four principal islands of the group, these stations to be so distributed north and south of the high mountains as to develop the amounts of deflection of the plumb-line. The latitude determinations were to be supplemented by determinations of the force of gravity at a station on top of one of the highest mountains, at a station at the sea-level, and at a station on Honolulu.

This project having met with the approval of the Secretary of the Treasury, Mr. E. D. Preston, of the Coast and Geodetic Survey, was detailed by the Superintendent to execute it.

Assistant Preston's full and comprehensive report of his methods of observation and the results of his work appears in Appendix 14 of this volume. The illustrations which accompany it add to its value as a paper of general scientific interest—one that has been referred to by high scientific authority as affording unexpected evidence on the doubtful questions relating to the density of volcanic mountains.

EXPLANATION OF ESTIMATES.

The estimates submitted to the Department for the fiscal year ending June 30, 1890, were accompanied by the following statement:

"U. S. COAST AND GEODETIC SURVEY OFFICE,
"*Washington, September* 21, 1888.

SIR: In transmitting for your approval the estimates of the appropriations required for the U. S. Coast and Geodetic Survey for the fiscal year ending June 30, 1890, I have the honor to submit the following explanation:

Exclusive of the estimates for printing and binding, which are the same each year, the aggregate of the estimates ($575,950) is larger than that for the current year ($559,885), an increase which is more than accounted for by the single item of $25,000 for the preliminary survey of the boundary of Alaska (frontier line between Alaska and British Columbia), a work originally estimated for by the Hon. Secretary of State, but which Congress has directed to be done by this Survey. With the Alaska boundary item omitted, these estimates would aggregate $8,935 less than those for the current year.

For the considerations which have governed the estimates for field-work I respectfully refer you to my letter transmitting estimates for the fiscal year ending June 30, 1888 (Appendix Gg, page 291, Book of Estimates), in which such considerations are given in detail.

For a full explanation of the class of expenditures mentioned as "party expenses," as well as the items in relation to the International Geodetic Association for the Measurement of the Earth, and in relation to a slight increase in the force of the computers, draughtsmen, and engravers, which matters have already been explained to and acted upon by Congress, I respectfully refer to my letter of October 6, 1887, transmitting the estimates for the fiscal year ending June 30, 1889 (Appendix Ii, page 312, Book of Estimates).

Of the increased estimates for "pay of office force," $2,000 is due to a transfer of an item for a computer in "publishing observations" to "chief accountant" under the head of "office force." The residue of such increase ($3,065) is due to estimates for a few deserved promotions, for a change of a messenger to a clerkship, and for payment of regular salaries for two additional map-colorists, whose necessary work has heretofore been paid for out of the item for "extra labor" under the sub-head of "office expenses," with the result of embarrassingly restricting the fund available for the remaining items of the paragraph "for miscellaneous expenses, contingencies, office furniture, repairs, etc.," as well as for the "extra labor," upon which constantly increasing demands are made in the furnishing of charts, tracings, drawings, soundings, and a great variety of data and information to the Engineers, U. S. Army, the Hydrographic Office, Navy Department, the Geological Survey, and other departments and bureaus of the Government, State, and municipal officers and individuals.

An increase of $6,000 is estimated for in the second paragraph of the "office expenses," in order to render possible the continuance of adequately prompt publication of the charts of the Survey, as explained to you in my letter of January 20, 1888, transmitting a so-called "deficiency estimate" for a similar purpose.

Respectfully yours,

F. M. THORN,
Superintendent.

The SECRETARY OF THE TREASURY.

ESTIMATES.

For every expenditure requisite for and incident to the survey of the Atlantic, Gulf, and Pacific coasts of the United States, and the coast of the Territory of Alaska, including the survey of rivers to the head of tide-water or ship navigation, deep-sea soundings, temperature and current observations along the coasts and throughout the Gulf Stream and Japan Stream, flowing off the said coasts; tidal observations, the necessary resurveys, the preparation of the Coast Pilot, continuing researches and other work relating to terrestrial magnetism, and the magnetic maps of the United States and adjacent waters, and the tables of magnetic declination, dip, and intensity, usually accompanying them, and including compensation, not otherwise appropriated for, of persons employed on the field-work, in conformity with the regulations for the government of the Coast and Geodetic Survey adopted by the Secretary of the Treasury; for special examinations that may be required by the Light-House Board or other proper authority, and including traveling expenses of officers and men of the Navy on duty; for commutation to officers of the field force while on field duty, at a rate to be fixed by the Secretary of the Treasury, not exceeding $2.50 per day each; outfit, equipment, and care of vessels used in the Survey, and also the repairs and maintenance of the complement of vessels, to be expended in accordance with the regulations relating to the Coast and Geodetic Survey from time to time prescribed by the Secretary of the Treasury, and under the following heads: *Provided*, That no advance of money to chiefs of field parties under this appropriation shall be made unless to a commissioned officer, or to a civilian officer who shall give bond in such sum as the Secretary of the Treasury may direct:

FOR PARTY EXPENSES:

1. To complete the triangulation and topography of the coast of Maine in Cobscook Bay and St. Croix River and to the International Boundary monument (all new work)	$6,000
2. For resurveys: For triangulation, topography, and hydrography in the vicinity of the east end of Long Island, Block Island, Nantucket, Nantucket Shoals and approaches, and including Vineyard Sound and Connecticut River to Hartford, Connecticut, and Hudson River to Troy, New York, and for current observations off Cape Cod	7,000
3. For current observations along the Sandy Hook and Coney Island shores, outside	3,000
4. For continuation of the comparison of the surveys of the Delaware River and Bay below League Island, and for observing the movement, lodgment of, and obstructions by ice, and alterations in the channels and bars caused thereby	2,000
5. To continue to date corrections of former surveys of the Delaware and Schuylkill Rivers on a new large scale chart of the same in the vicinity of Philadelphia and up the Delaware River to Trenton	1,000
6. To continue physical research and observation of the erosion by the sea on the coast of Cape Cod, Nantucket, and Martha's Vineyard, including reductions	2,700
7. For the hydrography of the inside waters and bars south of Absecon Light; for necessary triangulation and for continuing the topography along the Atlantic coast of New Jersey (nearly all of the hydrography is new work and the topography is virtually so because of the great changes)	3,000
8. For a hydrographic examination of Charleston, South Carolina, entrance and bar	2,000
9. To continue the primary triangulation from Atlanta towards Mobile	3,000
10. For a geodetic junction of Fernandina with Cedar Keys, including a line of precise levels	5,000
11. For continuing the survey of the western coast of Florida from Cape Sable north to Cape Romano, and for hydrography off the same coast, being all new work	12,000
12. For continuing the survey of the tributaries of Pensacola Bay, or, if completed, to run a line of standard levels from the bench-mark at Mobile to the bench-marks along the Mobile River up to the vicinity of Mount Vernon Landing	2,000

13. For the triangulation, topography, and hydrography of Perdido Bay and its connection with the coast triangulation, and for resurvey of Mobile Bay entrance, and, if completed, to take up the survey of Lake Pontchartrain.......	$3,000
14. For continuing the survey of the coast of Louisiana west of the Mississippi delta and between Barataria Bay and Sabine Pass..............................	7,000
15. To make off-shore soundings along the Atlantic coast, and current and temperature observations in the Gulf Stream..................................	8,000
16. For hydrography, coast of California, including San Francisco Bay and Harbor, and necessary triangulation and topography..................................	10,000
17. For continuing the topographic survey of the coast of California, including necessary triangulation and astronomical work in connection therewith	10,000
18. For continuing the primary triangulation of Southern California, and for connecting the same at Mount Conness with the transcontinental arc, and for a primary base-line in the vicinity of Los Angeles................................	10,000
19. For continuing the survey of the coast of Oregon, including off-shore hydrography, and to continue the survey of the Columbia River from the mouth of the Willamette towards the Cascades; triangulation, topography, and hydrography. (This amount is a necessary increase over last year's estimate, to meet the demands of the hydrography).................................	12,000
20. For continuing the survey of the coast of Washington Territory. (This amount is necessarily increased to meet the requirements of the hydrography)........	12,000
21. For continuing explorations in the waters of Alaska and making hydrographic surveys in the same, and for the establishment of astronomical, longitude, and magnetic stations between Sitka and the southern end of the Territory. (This estimate decreased, because experience proves that we can get along with $10,000)..	10,000
22. For continuing the researches in physical hydrography relating to harbors and bars, including computation and plotting................................	2,000
23. For examinations into reported dangers on the Atlantic, Gulf, and Pacific coasts...	
24. To continue magnetic observations on the Atlantic and Gulf slopes	1,200
25. For continuing magnetic observations on the Pacific coast, and at San Antonio magnetic observatory...	1,200
26. For running an exact line of levels from Boston or Salem, Massachusetts, to Blue Hill, Mount Monadnock, Mount Washington, Mount Independence, and Lake Champlain..	2,000
27. For continuing the exact line of levels from the point reached this year south of Cairo southward to Okolona, Mississippi, and, if junction is made, to continue the transcontinental line, beginning either in the vicinity of Kansas City or San Francisco...	3,000
28. For continuing tide observations on the Pacific coast, viz: At Kadiak, in Alaska, and at Saucelito, near San Francisco, California	2,500
29. To continue tidal observations on the Atlantic coast, at Sandy Hook, New Jersey, and at Savannah, Georgia..	2,100
30. For a self-registering gauge at Willets Point, Long Island, New York, to co-operate with the gauge at Sandy Hook, New Jersey, in securing data for the more complete study of the tides and tidal currents of East River and New York Harbor..	1,000
31. To continue gravity experiments, at a cost not exceeding $500 per station, except for special investigations and experiments authorized by the Superintendent at one or more stations..	5,000
32. For furnishing points to State surveys, to be applied as far as practicable in States where points have not been furnished..................................	10,000
33. For determinations of geographical positions, longitude parties..............	5,000

34. For continuing the transcontinental geodetic work on the line between the Atlantic and Pacific Oceans, including a primary base in the vicinity of Salt Lake	$30,000
35. To continue the compilation of the Coast Pilot, and to make special hydrographic examinations for the same	5,000
36. For traveling expenses of officers and men of the Navy on duty, and for any special surveys that may be required by the Light-House Board or other proper authority and contingent expenses incident thereto	3,000
37. For objects not hereinbefore named that may be deemed urgent	5,000
38. For contribution to the International Geodetic Association for the Measurement of the Earth, or so much thereof as may be necessary, $450, to be expended through the office of the American legation at Berlin; and for expenses of the attendance of the American delegate at the general conference of said association, or so much thereof as may be necessary, $550: *Provided*, That such contribution and expenses of attendance shall be payable out of the item "for objects not hereinbefore named," and after the adhesion by the Government of the United States to the convention of October, 1866, of the International Geodetic Association aforesaid.	
39. And ten per centum of the foregoing amounts shall be available interchangeably for expenditure on the objects named; in all, for party expenses	209,200

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, $25,000, said sum to continue available for expenditure until the same is exhausted	25,000

REPAIRS AND MAINTENANCE OF VESSELS:

For repairs and maintenance of the complement of vessels used in the Coast and Geodetic Survey	25,000

PAY OF FIELD OFFICERS:

For pay of Superintendent, $6,000 per annum	6,000
For pay of two Assistants, at $4,000 each per annum	8,000
For pay of one Assistant, at $3,600 per annum	3,600
For pay of one Assistant, at $3,200 per annum	3,200
For pay of two Assistants, at $3,000 each per annum	6,000
For pay of two Assistants, at $2,800 each per annum	5,600
For pay of three Assistants, at $2,700 each per annum	8,100
For pay of three Assistants, at $2,400 each per annum	7,200
For pay of three Assistants, at $2,300 each per annum	6,900
For pay of five Assistants, at $2,200 each per annum	11,000
For pay of six Assistants, at $2,000 each per annum	12,000
For pay of nine Assistants, at $1,800 each per annum	16,200
For pay of nine Assistants, at $1,500 each per annum	13,500
For pay of three Subassistants, at $1,400 each per annum	4,200
For pay of two Subassistants, at $1,300 each per annum	2,600
For pay of four Subassistants, at $1,100 each per annum	4,400
For pay of three Aids, at $900 each per annum	2,700
Total pay in the field $121,200: *Provided:* That no new appointments shall be made to the above force until the whole number of Assistants, Subassistants, and Aids shall be reduced to fifty-two	$121,200

PAY OF OFFICE FORCE:

For additional compensation to the Disbursing Clerk of the Treasury Department for the disbursement of the appropriations for the Coast and Geodetic Survey	$500
For one Chief Accountant, at $2,000, in lieu of computer publishing observations at $1,800	2,000
For one Accountant, $1,800	1,800
For one Accountant, $1,400	1,400
For one General Office Assistant, $2,200	2,200
For one Draughtsman, $2,350	2,350
For one Draughtsman, $2,100	2,100
For two Draughtsmen, at $2,000 each	4,000
For three Draughtsmen, at $1,800 each	5,400
For three Draughtsmen, at $1,400 each	4,200
For one Draughtsman, $1,330	1,330
For one Draughtsman, $1,260	1,260
For three Draughtsmen, at $1,200 each	3,600
For one Draughtsman, $1,100	1,100
For additional Draughtsmen, at not exceeding $900 each per annum	4,500
For two Computers, at $2,000 each	4,000
For one Computer, at $1,600	1,600
For one Computer, $1,400	1,400
For one Computer, $1,260	1,260
For one Computer, $1,100	1,100
For additional Computers, at not exceeding $900 each per year	2,700
For one tidal Computer, $2,000	2,000
For one tidal Computer, at $1,600	1,600
For one tidal Computer, $1,250	1,250
For three Engravers, at $2,100	6,300
For two Engravers, at $1,800 each	3,600
For two Engravers, at $1,600 each	3,200
For one Engraver, $1, 200	1,200
For one Engraver, $900	900
For additional Engravers, at not exceeding $900 per annum each	2,700
For engraving to be done by contract	7,100
For one Electrotypist and Photographer, $1,800	1,800
For one Electrotypist Helper, $600	600
For one Apprentice to Electrotypist and Photographer, $600	600
For one Copper-plate Printer, $1,700	1,700
For two Copper-plate Printers, at $1,330 each	2,660
For one Copper-plate Printer, $1,250	1,250
For two Plate Printer's Helpers, at $700 each	1,400
For one Chief Mechanician $1,800	1,800
For one Mechanician, $1,565	1,465
For one Mechanician, $1,330	1,330
For one Mechanician, $1,250	1,250
For one Mechanician, $1,200	1,200
For one Mechanician, $1,000	1,000
For one Mechanician, $600	600
For one Carpenter, $1,565	1,565
For one Carpenter, $900	900
For one Carpenter and Fireman, $600	600
For one Night Fireman, $550	550
For one Map-mounter, $1,020	1,020

For one Librarian, $1,800	$1,800
For one Clerk, $1,650	1,650
For one Clerk, $1,500	1,500
For one Clerk, $1,400	1,400
For one Clerk, $1,350	1,350
For three Clerks, at $1,200 each	3,600
For three Clerks, at $1,000 each	3,000
For one Clerk, $900	900
For one Clerk, $1,175	1,175
For three Map-colorists, $720 each	2,160
For one Writer, $840	840
For six Writers, at $720 each	4,320
For one Writer, $600	600
For one Messenger, $875	875
For one Messenger, $840	840
For two Messengers, at $820 each	1,640
For three Messengers, at $640 each	1,920
For one Driver, $730	730
For one Packer and Folder, $820	820
For one Packer and Folder, $630	630
For two Laborers, at $630 each	1,260
For two Laborers, at $550 each	1,100
For one Laborer, $315	315
For one Laborer, $365	365
For one Janitor, $1,200	1,200
For two Watchmen, at $880 each	1,760
Total pay of office force	$140,790

OFFICE EXPENSES:

For the purchase of new instruments, for materials and supplies required in the instrument-shop, carpenter shop, and drawing division, and for books, maps, charts, and subscriptions	$9,000
For copper plates, chart-paper, printer's ink, copper, zinc, and chemicals, for electrotyping and photographing; engraving, printing, photographing, and electrotyping supplies; for extra engraving and drawing, and for photolithographing charts and printing from stone for immediate use	16,000
For stationery for the office and field parties, transportation of instruments and supplies when not charged to party expenses, office wagon and horses, fuel, gas, telegrams, ice, and washing	6,000
For miscellaneous expenses, contingencies of all kinds, office furniture, repairs, and extra labor, and for traveling expenses of Assistants and others employed in the office, sent on special duty in the service of the office	3,500
And ten per centum of the foregoing amounts for office expenses shall be available interchangeably for expenditures on the objects named.	
Total general expenses of office	$34,500

RENT OF OFFICE BUILDINGS:

For rent of buildings for offices, work-rooms, and work-shops in Washington	$10,500
For rent of fire-proof building, No. 205 New Jersey avenue, including rooms for standard weights and measures; for the safe keeping and preservation of the original astronomical, magnetic, hydrographic, and other records; of the original topographical and hydrographic maps and charts, of instruments, engraved plates and other valuable property of the Coast and Geodetic Survey	6,000

PUBLISHING OBSERVATIONS:	
For one Computer, $1,600, and three Copyists, at $720 each; in all $3,760	$3,760
That no part of the money herein appropriated for the Coast and Geodetic Survey shall be available for allowance to civilian or other officers for subsistence while on duty in the office at Washington, or to officers of the Navy attached to the Survey; nor shall there hereafter be made any allowance for subsistence to officers of the Navy attached to the Coast and Geodetic Survey.	
PRINTING AND BINDING COAST AND GEODETIC SURVEY:	
For all printing and lithographing, photolithographing, photo-engraving, and all forms of illustration done by the Public Printer, on requisition by the Treasury Department, for the Coast and Geodetic Survey, namely: For Tide Tables; Coast Pilot; Appendices to the Superintendent's Annual Reports published separately; Notices to Mariners, circulars, blank books, blank forms, and miscellaneous printing (including the cost of all binding and covering; the necessary stock and materials and binding for the library and archives); $10,435...	10,435
ANNUAL REPORT:	
For 4,900 copies of the Annual Report of the Superintendent (including regular edition of 1,900 copies for Congress) viz: For composition, stereotyping, presswork, folding, inserting plates, binding material, etc., $8,000..................	8,000
For photolithographing, lithographing, photo-engraving, and all forms of illustration by the Public Printer for the Annual Report, $2,500....................	2,500
Total..	$20,935

NOTE.—No engraving is done by the Public Printer for the Coast and Geodetic Survey.

The following letter of transmittal was sent to the Department with the estimates for the expenses of the Office of Construction of Weights and Measures:

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, September 21, 1888.

SIR: Herewith I have the honor to transmit the estimates for the expenses of the Office of Construction of Standard Weights and Measures.

Respectfully yours,

F. M. THORN,
Superintendent.

The SECRETARY OF THE TREASURY.

OFFICE OF CONSTRUCTION OF STANDARD WEIGHTS AND MEASURES:	
For construction and verification of standard weights and measures, including metric standards, for the custom-houses, other offices of the United States, and for the several States, and mural standards of length in Washington, D. C.: One adjuster, at $1,500 per annum; one mechanician, at $1,250 per annum; one watchman, $720 per annum; in all $3,470..................................	$3,470
Contingent Expenses, Office of Standard Weights and Measures.—For purchase of materials and apparatus, and incidental expenses, $500	500
Provided, That such necessary repairs and adjustments shall be made to the standards furnished to the several States and Territories as may be requested by the Governors thereof, and also to standard weights and measures that have been or may hereafter be supplied to the United States custom-houses and other offices of the United States, under Act of Congress, when requested by the Secretary of the Treasury.	
For expenses of the attendance of the American member of the International Committee on Weights and Measures at the general conference provided for in the convention signed May 20, 1875, the sum of $600, or so much thereof as may be necessarry	600

PART II.

Beginning at the St. Croix River, Maine, and following the Atlantic and Gulf coasts to the Rio Grande, and beginning at San Diego and following a reversed geographical order on the Pacific coast, this part of the report contains abstracts of field-work derived from the reports of the chiefs of parties, including also those engaged in the States lying between the Atlantic and Pacific. Appendix No. 1 presents in tabular form the several sections into which, for convenience of reference, the coast and interior has been divided, states the nature of the several classes of work, the names of the officers in charge of field parties, and the localities of their surveys.

Notices of special operations and of the work of the Coast and Geodetic Survey Office and the sub-offices at Philadelphia and San Francisco follow.

The charge of the Office has been continued with Assistant B. A. Colonna. His annual report (Appendix No. 4) is accompanied by the reports of the chiefs of the several Office divisions. Mr. Colonna, in closing his report, alludes to the high state of efficiency that has been maintained in the Office, and expresses his thanks to the chiefs of the respective divisions and their subordinates. He acknowledges also the cordial co-operation of the Hydrographic Inspector and the naval officers associated with him.

Appendix No. 2 gives the statistics of field and office work of the Survey for the fiscal year, and a summation of those statistics to June 30, 1888. Appendix No. 3 presents in tabular form for the year the names of persons, associations, or Departments of the Government to whom information has been furnished, with a statement of the data or information supplied. The great increase in the work of requests for transcripts of the records and original surveys, both from official and personal sources in recent years, is one evidence of the increase in usefulness of the work and of a wider appreciation of the value of its results on the part of the public.

Lieut. Commander W. H. Brownson, U. S. N., has continued on duty as Hydrographic Inspector of the Survey. In his annual report (Appendix No. 5) he reviews the progress of the several classes of hydrographic work upon the Atlantic and Pacific coasts, refers to the advance made in the preparation of the Coast Pilot, and to the labors of the Hydrographic Division, states the condition of the vessels of the Survey, and makes recommendations for their repair, and submits suggestions for examinations and resurveys required to keep the charts up to date.

Under the general direction of the Hydrographic Inspector the duties of the Coast Pilot Division, which involved the execution of work both in the field and in the office, remained in charge of Lieut. George H. Peters, U. S. N., Assistant Coast and Geodetic Survey. The annual report of this officer accompanies the report of the Hydrographic Inspector. The collection, revision, and verification of data as carried on in the field is reported under headings in Sections I and II of the coast. A part of the large volume intended to include the whole of the Atlantic coast on a plan devised by Lieutenant Peters, has been put to press. This part includes the coast from Point Judith to the East River, and will be published as a special issue. Other portions of this volume are in active preparation, and those most in demand will appear at as early a date as practicable. Subdivision No. 21, Atlantic Local Coast Pilot, Tybee Roads to Jupiter Inlet (first edition), and Subdivisions Nos. 6 and 7, Cape Ann to Monomoy (third edition, in one volume), were published.

Ensign William J. Maxwell, U. S. N., was engaged in both field and office duty in the Coast Pilot Division up to the date of his detachment from the Survey, November 20, 1887. Ensign Edwin H. Tillman, U. S. N., served throughout the year; and as recorder and compiler, Mr. John Ross. After April 18, 1888, the charge of the Hydrographic Division devolved upon

Lieutenant Peters in the absence of its chief. Upon his leaving the office for field duty, in May, Mr. Tillman had immediate charge of the details of the office work of both the Coast Pilot and Hydrographic Divisions until the close of the fiscal year.

The annual report of the Hydrographic Division is submitted by Lieut. M. L. Wood, U. S. N., Assistant Coast and Geodetic Survey, who was in charge until temporarily detached, in April, 1888, for hydrographic duty in the vicinity of Cape Charles, Virginia. Lieutenant Wood calls attention to a change made in the system of supplying corrections to charts and in correcting copies of charts for issue whereby material reduction has been accomplished in the liability to error and in the labor of applying corrections. He suggests the possibility of making arrangements for printing the monthly Notices to Mariners and such occasional notices as are needed, in the office building, so as to shorten the time now required between the date of sending copy to the printer and the date of issue.

A large amount of work was completed during the year by the hydrographic draughtsmen attached to the Division, Messrs. E. Willenbucher, W. C. Willenbucher, F. C. Donn, and by Mr. E. H. Wyvill, who were assigned as hydrographic draughtsmen December 10, 1887. Tabular statements of their work accompany the report.

The clerical work in the Hydrographic Inspector's office was performed by Messrs. George J. Vestner, R. E. King, and W. H. Lanman until January 9, 1888, when Mr. J. H. Roeth was assigned to this duty. In the Coast Pilot Division, Miss Glova B. Bower was temporarily assigned to duty as copyist in April, 1888, and her work proving to be satisfactory she was employed in that capacity as a part of the office force from May 1.

Appended to Lieutenant-Commander Brownson's report are lists of officers of the Navy on duty in the Survey during the fiscal year, with dates of assignment and detachment, lists of naval officers attached to the Survey June 30, 1888, a list showing the number of naval officers attached to the several vessels and on office duty September 30, 1887, and March 19, 1888, and tabular statements of the number of men in service on the vessels at four different dates during the fiscal year, and of the names of the vessels, their tonnage, and complements of officers and men.

SECTION I.

MAINE, NEW HAMPSHIRE, VERMONT, MASSACHUSETTS, AND RHODE ISLAND, INCLUDING COAST AND SEA-PORTS, BAYS, AND RIVERS. (SKETCHES Nos. 1, 3, 17, and 18.)

Triangulation of Cobscook Bay, Maine, and of the St. Croix River, from the primary triangulation near its mouth towards the Initial Monument of the Northeastern Boundary at its source.—At the beginning of the fiscal year, Assistant C. H. Boyd had been in the field with his party since May 19, 1887, engaged in the triangulation of the north shore of Cobscook Bay, under instructions issued in April of that year. Two stations, in the towns of Edmonds and Pembroke, had been selected as forming a suitable base for beginning the work, these points having been carefully marked by copper bolts sunk into rocky ledges when first occupied in 1860. But upon reaching the field neither station could be found; the bolts had been broken out of the ledges, and in so doing the rock crushed and all traces of the drill holes destroyed.

Other station-marks searched for had similarly disappeared, so that ultimately the work had to be started from the line Carr–Little of 1866, and having been prosecuted without interruption until August, it was closed upon the station Prince Regent's Redoubt in Eastport.

On the northern shore of Cobscook Bay forty-five geographical positions were located in the towns of Edmonds, Dennysville, Pembroke, Perry, Eastport, and Lubec, intended to supply fully the needs of the topographic and hydrographic parties soon to follow.

In August the triangulation along the St. Croix River was taken up from the primary base Cooper–Chamcook. Station St. David's, formerly determined from this line, had disappeared, the owner of the land having removed the station-mark and built a house over it. Prince Regent's Redoubt was therefore occupied, and the work pushed northward at every available opportunity. Usually, in this locality, the months of September and October afford the best long-line seeing of the year, northwest winds clearing away the fogs, but this year these winds brought clouds of dense smoke from forest fires in Canada, so that the observations were greatly delayed.

Early in October Mr. Boyd was instructed to determine certain light-houses and other aids to navigation in the vicinity of St. Andrews, New Brunswick, their geographical positions being needed by the party engaged in the hydrography of the St. Croix River. This work involved the occupation of station Shortland of the Passamaquoddy Bay triangulation in connection with Chamcook. Lieutenant Crosby, U. S. N., Assistant, in charge of the hydrographic party, having established a tide-gauge on a wharf at Robbinston, which could be seen from Chamcook by erecting a signal upon the wharf-pile, this point was determined in position, and the reading of the high water on the staff, as given by Lieutenant Crosby, was transferred to a ledge on the Canadian side of the river near the base of Chamcook Mountain. A line of levels was then run from this bench-mark to the station on Chamcook. It being late in the season when this work was undertaken, Mr. Boyd acknowledges the service rendered in facilitating its completion by Assistant Ellicott, who transferred his foreman, Mr. E. M. Talcott, temporarily to Mr. Boyd's party.

Field-work was continued until November 21, when, in compliance with instructions, operations were closed.

Mr. R. H. Bayard, who was attached to the party during about half of the season, rendered capable and efficient service.

Mr. Boyd's report is accompanied by sketches showing the progress of his work, and by statistics, of which the following is a summary:

COBSCOOK BAY.

Number of signals erected	37
Number of stations occupied	14
Number of geographical positions determined	45
Area, in square statute miles, covered by triangulation	70

ST. CROIX RIVER.

Number of signals erected	12
Number of stations occupied	8
Number of geographical positions determined	22
Area of triangulation, in square statute miles (approximate)	500
Number of stations at which measurements of double zenith distances for differences of elevation were made	9

ST. ANDREW'S BAY.

Number of signals erected	2
Number of stations occupied	3
Number of miles of levels run	6

During the winter Assistant Boyd was engaged in office-work, and towards the end of April, 1888, was instructed to resume the triangulation of the St. Croix River from the limits of his work of the preceding season.

On June 1 he resumed field-work, and was occupied during the month in reconnaissance, re-adjustment and erection of signals, opening views, etc. Two stations were occupied for the measurement of ángles, and the signals put up extended the scheme of triangulation to the foot of Chiputneticook Lake.

Further report of this work will be made at the close of the next fiscal year.

Topographic survey of the west bank of the St. Croix River between Pleasant Point and Shortlands Station.—Instructions bearing date of June 8, 1888, were issued to Assistant C. M. Bache, directing him to proceed to Eastport, Maine, and organize a topographical party for the survey of the coast between Pleasant Point and Shortlands Station, on the west shore of the St. Croix River, extending the topography back from the shore line already completed, as far as necessary for purposes of commerce or defense, and in conformity with the work heretofore executed.

The interval between Mr. Bache's arrival at the locality of work and the end of the fiscal year was too short to admit of his doing more than to organize his party, put up the necessary signals, and make a beginning with the plane table. His progress will be further stated in the next Annual Report.

Hydrographic survey of St. Croix River, Maine, completed, and hydrography of Cobscook Bay, begun.—Reference was made in the last Annual Report to the beginning of the hydrographic survey of the St. Croix River, Maine, by the party in charge of Lieut. F. H. Crosby, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer *Gedney*. He had with him also the steam-cutter *Sprite* and the steam-launch *Sagadahoc*.

The hydrography of the St. Croix was executed on four sheets—scale 1-10000—the work extending from Eastport, Maine, to Calais, at the head of navigation, and occupying the party from the end of June till the middle of October, 1887. It was completed in accordance with instructions issued by the Superintendent and detailed instructions from the Hydrographic Inspector. The records and hydrographic sheets have been deposited in the archives of the Survey, and with the sheets are filed valuable descriptive reports submitted by Lieutenant Crosby in compliance with a recent circular. These reports give details of much local interest relative to the river channels, best anchorages, dangers, tidal currents, names of places, light-houses and other aids to navigation, pilots, harbor regulations, etc.

Similar descriptive reports, though necessarily less complete, accompany the single hydrographic sheet of Cobscook Bay, the only sheet that could be finished by Lieutenant Crosby's party before the close of the working season. This survey, begun September 21, in accordance with instructions issued towards the end of August, was continued till October 19.

The following named officers were attached to the party during the season: Ensigns A. W. Dodd, N. J. L. T. Halpine, R. O. Bitler, W. B. Fletcher, M. Johnston, and Joseph Strauss, U. S. N.

A general recapitulation of the statistics is as follows:

Number of miles run in sounding	1,311
Number of angles measured	18,195
Number of soundings	60,415
Area of soundings, in square miles	59
Number of tide-gauges erected	17
Number of specimens of bottom preserved	81
Number of stations occupied for observation of currents	6

In December Lieutenant Crosby was instructed to proceed to the Gulf of Mexico to execute hydrographic surveys on the coast of Louisiana, reference to which will be made under the heading of Section VIII.

Triangulation for the determination of light-houses and other points between Grand Manan Island and the coast of Maine.—The determination of the geographical position of several light-houses in the vicinity of Grand Manan Island having become desirable, and also the recovery of the primary station mark on that island, Assistant O. H. Tittmann received instructions about the middle of July, 1887, to execute that work, the requisite permission having been obtained from the Dominion Government to enter upon their territory.

Mr. Tittmann reached Grand Manan July 24, and having made a reconnaissance to lay out his work, occupied the station needed to determine the position of Seal Island Light-house, S. W. Head Light-house, Gannett Rock Light-house, and the beacon on Old Proprietor Ledge. Clear weather and a calm sea being essential conditions of the work, many delays were experienced in its prosecution.

While occupying the Machias Seal Islands, measurements were made of the elevation of the lights above an approximate high-water line, and as errors were found in the published lists affecting the computed range of visibility, a special report was made by Mr. Tittmann on the subject.

The light-houses and the outlying-dangers to the south and southeast of Grand Manan were connected properly with the triangulation on the coast of Maine.

During the course of the work angles were observed and measurements of distances made to determine the location of Grand Manan primary station, which was supposed to have been lost or destroyed. It was finally found upon Sinclair Hill, on the southeast side of Dark Harbor, marked by a triangle cut upon the top of the out-cropping rock.

Field operations were closed September 19, and the records and computations of the work forwarded soon after to the Office.

Upon returning to Washington in October, Mr. Tittmann was assigned to the charge of the Office of Weights and Measures.

Inspection of topographical work upon the coast of Maine.—Towards the end of July, 1887, Assistant Charles Hosmer proceeded to the coast of Maine, under instructions to inspect the topography upon that coast in the vicinity of Machias, and thence to Quoddy Head and around the coast into Cobscook Bay, and upon the completion of that duty to take up a topographical survey on Cobscook Bay.

Part of his inquiry was directed to a comparison of the shore line and other topographical features, as delineated by recent surveys and by those made upwards of twenty-five years ago.

Mr. Hosmer had made good progress in the execution of this duty, and kept the field, though suffering from ill health, until early in October, when, by the advice of his physician, he returned to his home. On the 28th of that month he died.

As an officer of the Survey Mr. Hosmer's record was one of faithful and honorable service during thirty years.

Topographical survey of Cobscook Bay, Maine.—During the summer and autumn of 1887, Assistant Eugene Ellicott continued the topographical survey of the western part of Cobscook Bay, reference to the progress of which was made in the last Annual Report. Field operations were begun May 1 and closed November 14, the scale of survey being 1–10000.

Mr. Ellicott has submitted with his topographical sheet a descriptive report, in which he gives much detailed information respecting the character of the country over which his survey extended; its geological and topographical features, the proportions of arable and wooded land, the chief industries, etc. The Cobscook Falls present a somewhat remarkable physical feature. Between the northwest coast of Falls Island and the main land in the town of Pembroke is a narrow passage, the rapid rise and fall of the tides through which causes a difference of level in the inner and outer basins immediately adjacent of about 2.6 feet at flood tide in a distance of 130 feet. The noise produced by the rushing waters can be heard two miles off.

The statistics of Mr. Ellicott's survey are as follows:

Miles of shore-line surveyed	75
Miles of roads surveyed	28
Area of survey, in square miles	23

During the following winter and spring Mr. Ellicott was engaged on office duty, and about the middle of May took up, under instructions, the continuation of his work of the preceding season, beginning with the topography of the north side of Cobscook Bay, in which were included the towns of Pembroke and West Pembroke.

Between the time of resuming field operations and the end of the fiscal year, Mr. Ellicott confined his efforts to the delineation of the more salient points of shore-line, and to those parts of the inland topography within easiest reach. He will make a detailed report at the end of the season.

Continuation of the topographical survey of the south and north branches of Cobscook Bay, Maine.—At the beginning of the fiscal year Mr. J. H. Gray, Aid in the Survey, was in the field in charge of a topographical party organized for work upon the south branch of Cobscook Bay. This work he had begun May 21. A reference to its progress up to June 30, 1887, was made in the last Annual Report. Field-work was carried on until October 18, when the party was disbanded and operations closed for the season. The statistics from the beginning of the fiscal year are:

Miles of shore line surveyed	31
Miles of roads surveyed	21
Area of survey, in square miles	14

Mr. Gray has submitted a descriptive report, which has been filed with his topographical sheet in the archives.

During the early part of the winter Mr. Gray was employed in office-work, and in January, 1888, was instructed to join the party of Assistant Jos. Hergesheimer on the west coast of Florida.

Early in June, 1888, having returned from Florida, he proceeded, under instructions, to the coast of Maine, and organized his party for the survey of the north branch of Cobscook Bay. Progress was less rapid than could be desired on account of the many ledges for which low-water line had to be obtained. The statistics for the season will be given in the next Annual Report.

Hydrographic examinations on the coast of Maine for the Atlantic Coast Pilot.—At the beginning of the fiscal year the steamer *Endeavor* was being refitted at the New York Navy-yard, the Coast Pilot party, in charge of Lieutenant G. H. Peters, U. S. N., Assistant Coast and Geodetic Survey, having been transferred to her from the steamer *Daisy*. About the middle of July the *Endeavor* proceeded to Portland, Maine. Data for the Coast Pilot was collected in Casco Bay and its tributaries till August 8, when Lieutenant Peters proceeded eastward, making examinations during the rest of the month in Penobscot Bay and its numerous harbors, and in Frenchman's Bay and the waters adjacent. The work was then carried eastward as far as Eastport.

Leaving that port September 11 the *Endeavor* proceeded westward, devoting as much time as practicable to points requiring further attention. On September 24 Lieutenant Peters left Portand, making some examinations to the southward when the weather would permit. At New Haven, Connecticut, he received instructions to proceed to New York, where he arrived with the *Endeavor* October 8.

Soon after the steamer was laid up at the New York Navy-yard, and the Coast Pilot party detached to resume duty at the Office.

During the season special hydrographic examinations were made from time to time in consequence of information received while carrying on the regular work of the party. In cases where these examinations developed dangers not already shown on the charts, or depths less than had been indicated, the results were reported to the Hydrographic Inspector.

Fog interfered materially with the work, and during September an unusually smoky condition of the atmosphere; but, upon the whole, the results of the season's work were satisfactory, being such as to warrant the immediate preparation of a volume now in hand, to cover the coast of Maine.

Lieutenant Peters acknowledges the zealous service rendered in the work by Ensign W. J. Maxwell, U. S. N., and Mr. John Ross.

Completion of the record of tidal observations at the automatic tidal station at Pulpit Cove, North Haven Island, Penobscot Bay, Maine.—For the study of the characteristics of the tides of the Gulf of Maine a self-registering gauge was established in January, 1870, at Pulpit Cove, North Haven Island, Penobscot Bay, and placed in charge of Mr. J. G. Spaulding.

On March 28, 1888, an almost unbroken record having been kept up throughout a lunar cycle, the observations were discontinued, there being greater need of extended tidal series at other stations on the Atlantic coast.

During the last year the observations were fully up to the standard of excellence maintained by Mr. Spaulding since the beginning of the series. His uniform faithfulness and efficiency in duty deserves high commendation. In April he was transferred to the charge of the automatic tidal station at Sandy Hook.

Magnetic observations at stations in Maine and Massachusetts.—Instructions issued to Assistant James B. Baylor about the middle of July, 1887, directed him to occupy a number of magnetic stations in the New England States, at which magnetic observations had been obtained in former years, in order to secure additional data for the determination of the secular variation of the magnetic declination, dip, and intensity, and also to establish some new stations in those States, and one in Washington, D. C.

Having executed the duty last mentioned, reference to which more in detail will be found under the heading of Section III, Mr. Baylor proceeded to the State of Maine, and began his magnetic work there by the occupation of a new station at Damariscotta, Lincoln County, establishing it in an open lot in front of the Methodist church. Time, latitude, and azimuth were determined by observations on the sun August 4, 5, and 7, and the magnetic declination, dip, and intensity on August 5, 8, and 9.

A new station was next established at Millbridge, Washington County, Maine, on the hill north of the Christian church. Time, latitude, azimuth, and the magnetic elements were determined here by observations made August 13.

At Machiasport, Maine, a new station was established in the Government reservation at Fort O'Brien. Time, latitude, and azimuth were determined August 19, and the magnetic elements August 20.

The station of 1879, in the center of the parade-ground at Fort Sullivan, Eastport, was re-occupied for the determination of the magnetic elements on August 24 and 26. Time and azimuth were determined August 23 and 26.

At Presque Isle, Aroostook County, Maine, a new station was established in the open park in front of the Phair Hotel, on Main street. Time, azimuth, and the magnetic elements were determined August 30 and 31.

At Houlton, Aroostook County, a new station was established over one of the granite piers at Hancock barracks, just east of the town. Time, latitude, azimuth, and the magnetic elements were determined by observations made September 5, 6, and 7.

At Vanceboro, Washington County, a new station was established in the open lot north of the Roman Catholic church. Time, latitude, azimuth, and the magnetic elements were determined by observations made September 10, 12, and 13.

At Danforth, Washington County, a new station was established on the hill in front of District School No. 5, and observations made for time, latitude, azimuth, and the magnetic elements on September 15 and 16.

At Mattawamkeag, Penobscot County, a new station was established in an open lot on Main street, south of the postmaster's house. Time, latitude, and azimuth were determined on September 17 and 18, and the magnetic elements September 19.

A new station was next established at Greenville, Piscataquis County, its location being in an open lot north of the Lake House and to the east of the south cove of Moosehead Lake. Time, latitude, azimuth, and the magnetic elements were determined here on September 24.

At the Maine Central Institute, Pittsfield, Somerset County, a new station was established in the grounds of the Institute, southwest of the main building, and observations made for time, latitude, and the magnetic elements, September 29 and 30.

A new station was established at Farmington, Franklin County, in the flats of Sand River, and just north of Prescott's factory, on Depot street. On October 6 and 7 observations were made for time, latitude, and azimuth, and the magnetic elements.

It had been intended to re-occupy one of the old stations on Bramhall Hill, Portland, Maine, but it was found that a house had been built over the site of the station of 1864 and 1865, and that the proximity of electric wires had made the stations of 1859 and 1863 unavailable. It became necessary, therefore, to occupy a new station, and this was established in the grounds of Mrs. J. B. Brown, as near the former station as practicable. Observations for time, azimuth, and the magnetic elements were made here on October 13, 14, and 15.

At Plum Island, near Newburyport, Massachusetts, a station was established as near the station of 1859 as the changed surroundings would permit. Time, azimuth, and the magnetic elements were determined October 18, 19, and 20.

At Fort Lee, near Salem, Massachusetts, the station of 1855, in the center of the old fort, was re-occupied. Time, azimuth, and the magnetic elements were determined October 22 and 23.

The funds available for the work having become exhausted after the occupation of the last named station, Mr. Baylor was instructed to suspend field operations for the season, and take up the computation of his observations. His records and results are now in the Office.

In December he was temporarily assigned to duty in connection with gravity work, reference to which is made under a heading in Section III.

Determination of boundary lines of towns in the State of Massachusetts.—In connection with the topographical survey of the State of Massachusetts, of which Assistant Henry L. Whiting is, by special assignment, one of the Commissioners, the work of determining the boundary lines of townships in the State was prosecuted during the season of 1887 under Mr. Whiting's general direction by Assistants Gershom Bradford and C. H. Van Orden.

Reference to this work, and to the instructions under which it was again taken up, in April, 1887, was made in the last Annual Report. Messrs. Bradford and Van Orden have each made special reports of their surveys, abstracts of which are as follows:

Beginning in Wareham Township, at the head of Buzzard's Bay, in Plymouth County, Mr. Bradford carried his work to the westward, and at the close of field operations, November 29, had established in geographical position the boundary lines of Wareham, Marion, Mattapoisett, and Rochester, in Plymouth County, and of Fair Haven, Acushnet, New Bedford, Dartmouth, Westport, Fall River, and Somerset, in Bristol County, besides incidentally determining parts of the boundary lines of the townships of Middleborough, Freetown, Dighton, and Swansey, bordering upon the above.

It was agreed by Messrs. Bradford and Van Orden to adopt a uniform method of numbering the town corners by beginning at a southwestern corner and numbering consecutively from that round by west, prefixing the name of the township, as Acushnet 1, and so on.

The heights of many of the stations were determined with a vertical circle, and were referred to the ground and to high-water bench-marks upon rocks at Cromeset Neck, in Wareham and Clark's Cove, New Bedford. Elevations in Fall River, derived by the City Engineer from levels to the Coast and Geodetic Survey bench-mark there, were also made available.

For the triangulation, bases were generally obtained by lines joining points of the Coast and Geodetic Survey and the Borden State Survey, the latter having been previously adjusted in the office to conform to standard geodetic data. The principal base stations were Monk's Hill, Alden, Great Hill, Mendal, New Bedford Court-house, and Copecut.

Mr. Bradford observes that to determine in position marks placed with no reference to the question of intervisibility, and often in wooded swamps, difficult of access, presented difficulties of a peculiar nature. These were overcome, after a number of devices had been tried, by the use of flagged poles in trees adjacent to the boundary marks. The poles were secured steadily in position by guys, and elevations of one hundred feet above the ground were thus attainable, enough to overtop the wooded hills. To these poles the boundary marks were referred by a compass course and a distance measured from a point plumbed under the part of the pole observed upon to the mark. These compass courses were run by an engineer's transit, with which direct and reverse bearings were taken between the pole and the mark, measurements of distance being made with a steel tape. Observations were, of course, made directly upon the boundary marks or upon signals plumbed over them whenever practicable.

Mr. Bradford furnishes the following statistics of his work from its beginning, April 20, till its close, October 29:

Number of township boundaries completed	10
Number of township boundaries partially completed	5
Number of triangulation stations identified	21
Number of new stations located	144
Number of stations occupied for observing	79
Number of stations observed on	122
Number of signals built	83
Number of boundary marks located	60
Number of points of triangulation marked permanently with stone monuments	19
Area of survey (approximate), in square miles	252

Mr. Van Orden having reported to Mr. Whiting April 26, was directed to take up the determination of township boundary lines on the peninsula of Cape Cod. Beginning at the northern end of that peninsula, his first work was to find the six stone monuments between the towns of Provincetown and Truro. The base lines Cape Cod Light-house to Wood End Light-house, and Cape Cod Light-house to Long Point being available, and the country an open one, but little difficulty was experienced in connecting these monuments with the triangulation. The importance of making this connection is shown by the constant danger to which the fifth and sixth stones were exposed, of being covered up by the shifting sands or washed out by the encroachments of the sea; and as a means of deciding upon changes in shore-line due to such encroachments the securing of boundary stones on the peninsula or the practicability of reproducing their positions in the event of loss is very desirable. On the harbor side, the positions of boundary stones become of much importance to the fishing interests of townships. During the preceding season the location of the bay-shore monument between Wellfleet and Eastham had become the subject of a dispute which was eventually brought before the State legislature.

From Provincetown to Chatham the work progressed rapidly, but from Chatham to the Plymouth line the boundary stones were generally in dense woods or hollows, and the country being, as a rule, heavily wooded, with no prominent hills, Mr. Van Orden met with difficulties similar to those already adverted to. But by availing himself of similar expedients in regard to signals, and by laying out schemes of small triangles to reach the boundary stones, basing these triangulations on points well determined by the Government and State Surveys, he was enabled to complete all of his determinations satisfactorily.

While at Barnstable, in compliance with a request from the Chairman of the County Commissioners, and with the approval of Mr. Whiting, Mr. Van Orden examined the county meridian line, connecting it with the triangulation and determining its azimuth.

In connection with the town boundary survey, it was deemed advisable by the State Commission to determine a series of accurate level bench-marks throughout the State, and this work was begun by Mr. Van Orden by running a double line of levels from Orleans station to Sagamore station on the Old Colony Railroad, and a single line from there to the bench-mark of the Cape Cod tide-gauge. A double line was also run from Harwich station to Harwich Exchange in Harwich Center, and a single check-line from Barnstable station to assumed high water. Brewster station was connected with the main line by a double line of levels. The whole line, so far run, is permanently marked by copper plates secured to the station and freight houses of the Old Colony Railroad.

Field operations were closed December 2. For the season the statistics are:

Number of township boundaries completed	11
Number of township boundaries partly completed	4
Number of stations occupied	118
Number of signals built	166
Number of points determined, including 74 town corners	296
Number of miles of levels run	82
Area of survey, in square miles	390

Physical hydography, coast of Cape Cod Peninsula.—Upon the completion of the physical surveys in New York Harbor early in August, 1887, Assistant H. L. Marindin was instructed to re-organize his party as a shore party, with a camp at the entrance of Nauset Harbor, Cape Cod, and take up a survey, the object of which was defined in a memorandum furnished by Assistant Henry Mitchell. The principal points of this memorandum were as follows:

1. Tidal observations and levelings for the determination of stages and slopes on the sill of Vineyard Sound, and for planes of reference of both topography and hydrography.

2. To extend the shore-line and crest-line surveys along the outside shore of Cape Cod to the limits of the shoal building supply, the work to include slopes of bluffs, sections of barrier sands, and submerged contours out to four fathoms of water.

The work as thus laid out was closely prosecuted throughout the season. On the 30th of August the field-work proper began by the location of a longitudinal section of levelings along the coast from the inlet into Nauset Harbor to Nauset Three Lights. This longitudinal section was designed to form the back-bone of the cross-sections running out to seaward through the line of breakers and normal to the shore. It was extended during the season by lines of precise leveling along Nauset Beach to the bench-mark near the tide-gauge at Harding's Beach. The cross-sections were located and measured at an average distance apart of three hundred meters (984.3 feet). Each cross section was leveled and joined to the longitudinal section, which was connected by precise leveling with the tidal bench-marks established during the season. The levels at each cross-section were carried out into the water at the time of low water or near it, and the soundings taken on these sections were obtained as near the high-water stage as the circumstances would permit, with the object of overlapping the points reached by the level from shore. By sounding at or near the time of high water, and backing the whale-boat almost on the breaker, the first sounding was obtained very near to, if not overlapping, those points where the strand was laid bare by the retreat of the tide.

It was proposed to show from the observations the position of the low-water line with the ocean at rest; also the position of a mean-level line, and that of high water with the ocean at rest. The high-water line as obtained by the plane-table is not the same as that noted above, but rather a line defining the reach of the seas at the next preceding high water. The location and heights at the foot of the bluffs were also to be given, these being the lines of greatest erosion reached by the sea only during severe gales.

Permanent bench-marks were established at the inlet into Nauset Harbor, on Pochet Island, on Chatham North Light, on Harding's Beach Light-house, on a fish-packing stand near the tide-gauge on Harding's Beach, and on a house belonging to Seth Mallows at the Powder Hole, Monomoy Point. These benches, with the exception of the one last named, were connected by two lines of precise levels, run in opposite directions and aggregating a length of twenty-eight miles. Numerous temporary benches were established in connection with the permanent ones.

The tide-gauges at Nauset Harbor, at Chatham Beach (outside), at Harding's Beach, and at Powder Hole were observed simultaneously night and day for eight days, and during the same period the turning of the tidal current was observed at the Handkerchief, Pollock Rip, and Shovelful Light-ships.

The line of precise levels joining the tide-gauges at Harding's Beach with those at Chatham and Nauset Harbor was completed early in November, and on the 7th of that month the party was disbanded.

Mr. Marindin acknowledges the efficient aid rendered in the work by Messrs E. E. Haskell and Homer P. Ritter, experts in physical hydrography. His elaborate report, of which the foregoing is only an abstract, is accompanied by a sketch showing the locality of the survey and the positions of the tide gauges and bench-marks. He will ultimately submit a descriptive report to accompany the two sheets of physical hydrography on which the results of the survey are shown.

Reference will be made under a heading in Section II to Mr. Marindin's work in New York Harbor, which immediately preceded that on Cape Cod. The statistics which follow include the surveys of 1887 in both localities:

Number of cross-sections located and measured	54
Number of stations occupied for observations of currents	45
Number of current observations registered	4,169
Number of observations of specific gravity	704
Number of soundings on cross-sections	2,639
Number of angles taken for locating stations and soundings	1,032
Number of tidal stations established and occupied	5
Number of miles of levels of precision run	28
Number of miles of spirit leveling	15
Number of permanent bench-marks established	7
Number of specimens of bottom preserved	19

After the disbanding of the field party, Mr. Marindin joined the United States Advisory Commission for the port of Philadelphia, in his official capacity as Secretary of that Commission by special assignment under instructions from the Superintendent. He remained on this duty, with an interval of absence on leave, until early in February, 1888, when he reported for duty at the Office. Messrs. Haskell and Ritter had reported at the Office in November.

During the period from February 10 till early in June Mr. Marindin was occupied with the computations and drawings required to show the results of physical hydrographic surveys in New York Bay and Harbor and on Monomoy Shoals and the beaches adjacent. His elaborate report on the tidal levels and flow of currents in New York Bay and Harbor, with drawings accompanying, was submitted May 15, and will be published as Appendix No. 9 to this volume.

In June, this office-work having been completed, instructions for field-work received during the preceding months took effect, and proceeding to Cape Cod, with Messrs. Haskell and Ritter as expert observers, and Messrs. Wedekind and Stone as recorders, Mr. Marindin went into camp at North Chatham, Cape Cod, in order to close a gap between Lieutenant Pillsbury's work of the previous year and his own during the preceding season. Appropriate cross-sections were laid out three hundred meters apart, on which both levels inshore and soundings seaward would give a mold of the beach from which such changes as would occur in the future could be accurately ascertained.

The trials made of a new form of tide-gauge devised by Mr. Marindin for use on a coast subjected to heavy ocean swells were not satisfactory, but the difficulties which prevented its successful working were carefully noted, and in the end it is hoped that they will be overcome.

At the close of the fiscal year work was still in progress. Up to that time the statistics reported are:

Number of cross-sections laid out and measured	8
Number of cross-sections laid out and leveled	7
Number of elevations determined on cross-sections	166
Number of bench-marks referred by levels	2
Number of tidal stations established	2

Triangulation of Nantucket and Vineyard Sounds and topographical surveys on Nantucket and Martha's Vineyard.—Resurveys on Nantucket and Martha's Vineyard having become desirable by reason of changes in the configuration of shore-line during periods ranging from thirty to forty years, the parties organized for that work during the summer and autumn of 1887 were placed under the general supervision of Assistant Henry L. Whiting, by instructions issued towards the beginning of the fiscal year. Assistant W. I. Vinal, Subassistant R. A. Marr, and Aid E. L. Taney were directed to report to Mr. Whiting by instructions issued towards the end of June. To Mr. Vinal he assigned the resurveys of shore-line and localities adjacent on Martha's Vineyard, to Mr. Marr the triangulation of Nantucket and Vineyard Sounds, and to Mr. Taney the topographical resurveys on the island of Nantucket.

From a general review of the results presented by the work, Mr. Whiting has submitted a report based upon comparisons of these and former surveys.

Mr. Taney's work, which, in addition to the resurvey of the Nantucket shore-line, included that of the small islands of Tuckernuck and Muskeget, and the still smaller beach islands and shoals surrounding them, called for but little interior topography, the features of the shore being simpler in character than on Martha's Vineyard, with fewer artificial details subject to change. Almost the only exception was at Siasconset, where some cottages and larger buildings have been added to the quaint settlement as it was forty years ago. The changes in the position of the immediate shore, particularly along the south side and at the west end of the island, have, however, been much greater in general results than on Martha's Vineyard.

Great Point, the southeasterly headland of Nantucket Sound, that most important highway for coastwise vessels, has, as Mr. Whiting observes, undergone important changes, according to history and trustworthy testimony, affecting in former years the navigable limits of the water way between it and Monomoy Point. But now it is to be noted that the extremity of Great Point is in almost the exact geographical position that it was forty-one years ago. The shape of the point is now somewhat less sharp. About one-eighth of a mile south of the extreme point on the inner side, the shore-lines of 1846 and 1887 coincide exactly.

After giving further details of changes in the shore-line, Mr. Whiting states that in general terms the changes of Great Point indicated by the two surveys have resulted in the narrowing of the southerly part with a broadening of the last three-fourths of a mile at the extreme end. Along the eastern side of the island, and from Sankaty Head south and west there has been alternately waste and gain, one of the most marked instances of the latter being in the form of a long outward sweep or wave in the shore-line, extending for about two and a half miles, having a width at Sankaty Head of about one hundred feet; about one mile southwest of the Light-house four hundred feet; off Siasconet Village two hundred and fifty feet, and beyond this again a width of about three hundred and fifty feet. Beyond the present point where the lines of waste and accretion cross each other, and for about three-fourths of a mile southwest and westerly to about opposite Tom Nevers Pond, a former outward bend in the shore has been washed away, the greatest waste in width being about six hundred feet.

Attributing these sweeps or waves to resultant effects of sea-dash and littoral currents, Mr. Whiting remarks that the same character of formation and movement is observable along the outer shore of Cape Cod, particularly between Highland Light and Race Point.

With regard to Muskeget Island and the beaches south of it, and Tuckernuck Island, Mr. Whiting refers to notable changes indicated by the last resurvey, the character of which indicates a general receding to the northward and eastward of the ocean boundary, and the driving back of the high-water line by the forces which throw the sands up above high water. Details of these changes are given in his report, which is accompanied by a tracing from the surveys of 1846, 1856, and 1887.

Along the east shore of Martha's Vineyard the changes which have taken place within the scope of Mr. Vinal's survey in the interval of forty-one years since the first survey was made, are not of special physical importance, and do not affect matters of navigation. The waste of the bluff at the East Chop of Vineyard Haven Harbor has not been as much since 1871—the ratio not so great as it was between 1846 and 1871. This is probably owing to the influence of the recent structures along this part of the shore, whereby the littoral movement of the sands has been arrested. The same may be said of the ratio of change at West Chop.

The first survey of this point by the Coast Survey was made by Mr. Whiting in 1845; the next one, in 1871, was made by him also. A comparison of the results of these surveys with that of 1887 shows that some changes have taken place in the outline and material of the Chop, and of the sound and harbor shores on either side of it. After giving details of his comparisons Mr. Whiting states that there is no evidence of extensive recent waste at West Chop by either wave or current action, and that it is an important fact that at this most salient point on Martha's Vineyard, making the greatest contraction in the width of the sound between the shores of the island and the main land at Nobska Point, but little, if any, change has occurred in the geographical position of the high-water line since the date of the survey of 1845.

At the point of Cape Poge the waste of beach and bluff has been greater than at any other place in this part of the island, being about three hundred and twenty-five feet. Along the shore of Chappaquiddick Island, from the entrance to Cape Poge Pond to the long point of the island opposite Edgartown Village, there has been no marked change.

A resurvey of the New South Inlet into Cotamy Bay, including a short reach of the shores on either side of it, showed that a remarkable change had taken place in the position of this inlet between the dates of the surveys of 1886 and 1887, a period of fifteen months. During this time the position of the inlet has moved a distance about equal to its width, namely, about twelve hundred feet, the point of beach forming the westerly chop of the inlet being now about where the easterly chop was last year. The easterly point has moved still farther eastward, so that the inlet is now about five hundred feet wider than it was in 1886, being on October 26, 1887, about sixteen hundred and forty feet in width. The general position of the beach west of the inlet does not seem to have undergone much change, but east of it the mass of the beach has been beaten inward to the north for about a mile, as far as the resurvey extended. The greatest movement was at the point which was found to be about three hundred and tweny-five feet farther inward than its position in 1886. These changes gave an additional basis for Mr. Whiting's prediction, referred to in the last annual report, that the inlet would eventually work eastward. The rapidity of this movement has, however, been greater than was anticipated. At the same rate of progress the westerly point of the inlet will reach the line of the fast land of Chappaquiddick in about six years, where it will again be in the same condition and subject to the same forces that caused it to close in 1869.

It was thirteen years in making an equal previous movement. Mr. Whiting's report on the shore-line changes on Martha's Vineyard (Appendix No. 9, 1886) is accompanied by a map showing changes in Cotamy Beach from surveys made in 1846, 1856, 1871, and 1886, with special reference to the opening and closing of former inlets.

Other duty assigned to Mr. Whiting, in connection with the Massachusetts State Survey, is referred to under a separate heading in this section.

In addition to the duties here referred to, and those relating to the resurveys of town boundaries in the State of Massachusetts, Mr. Whiting was occupied, under instructions issued early in November, 1887, in continuing and completing the marking of the points of triangulation determined by Mr. Marr on Nantucket and Martha's Vineyard.

After the close of the work of the several field parties, he was authorized to retain and ink the topographical sheets of Mr. Taney's survey of Nantucket. This duty occupied him during the most of the winter and spring, though occasionally interrupted by necessary service for Massachusetts as Secretary of the Board of the State Commissioners. He had also office occupation in preparing some samples for topographic representation of the rocky shores of the coast of Maine.

As preliminary to future field operations, he submitted on March 8, 1888, a scheme for continuing the topographical resurveys of Vineyard Sound and vicinity. His first active duty in connection with field operations was in conference with Mr. Van Orden, relative to his proposed continuation of the town boundary work of 1887. Mr. Van Orden took the field May 27, in Barnstable and Plymouth Counties, Massachusetts, to complete and close up the triangulation of 1887 in the former county, and to connect with the work of 1885 in the latter. This work was in successful progress at the close of the fiscal year.

In pursuance of instructions, Assistant Vinal reported for duty about the middle of June, and was assigned to the resurvey of Wood's Holl, harbors and passage way, with the connecting topography in Falmouth and on Naushon Island on a scale of 1–5000. Reference to Mr. Vinal's report of this work is made under a later heading in this section.

Triangulation of Nantucket and Vineyard Sounds.—The triangulation incident to the resurveys on Nantucket and Martha's Vineyard, and the adjacent islands, was assigned to Sub-assistant R. A. Marr, by instructions issued June 20, 1887, and was executed in accordance with the views and suggestions of Assistant H. L. Whiting.

Upon Nantucket and its outlying islands, Tuckernuck and Muskeget, the triangulation was carried forward from two of the old stations, Shawaukemo and Gibbs' Pond, that had been recovered by Mr. Taney; it was connected also with the fixed points, Great Point Light, Sankaty Head Light, South Church Spire, and Tuckernuck Telegraph. The interior points, Weeweeder Life Saving Station and Meridian, were determined in order to have ready reference stations for future use in case of marked changes in the island.

Meridian station is the south post of three which mark the prime meridian of the island of Nantucket; these are handsome hexagonal granite posts, with bronze caps, bearing the cardinal points, and were put up under contract for the State. Their connection with the triangulation developed an error in the position of the north post, its bearing being 28′ 05″ east of north from the south post.

On Martha's Vineyard the old stations of Indian and Prospect Chilmark were intact, and this line was used as a base. The hydrographic signals which had been established on both shores of the sound were determined in position as well as other points necessary for the topographical surveys.

By means of a striding level attached to the telescope it was found that Peaked Hill was about four feet higher than Prospect Chilmark, which has hitherto been supposed to be the highest elevation on Martha's Vineyard.

Under Mr. Whiting's direction the stations on Martha's Vineyard, Nantucket, and No Man's Land were marked with solid granite posts, or with drill holes in surface bowlders. The instruments and stand were mounted at each station according to a plan devised by Mr. Marr and referred to in the report of his work at Cape Charles, Virginia, under heading Section III.

The statistics of field-work, which was begun July 28 and finished October 31, are as follows:

Number of signals erected	30
Number of stations occupied	23
Number of objects observed upon	93
Number of new points determined	60

During the winter Mr. Marr was engaged in office-work, and early in April was assigned to the charge of one of the longitude parties on the Pacific slope. Reference to this duty will be made under the head of Section XI.

Topographical resurvey of the shore-lines of Nantucket, Muskeget, Tuckernuck, and the small islands in their vicinity.—Reference has been made under a previous heading in this section to the assignment of Subassistant E. L. Taney to the charge of topographical resurveys on Nantucket and the small islands in its vicinity under the general supervision of Assistant H. L. Whiting, and an account of Mr. Taney's work has been given as derived from the full report of Mr. Whiting.

Points were determined for the plane-table survey from the old triangulation stations, Gibbs' Pond and Shawaukemo, which Mr. Taney succeeded in recovering. From these and Great Point Light and Brant Light, he made a plane-table triangulation of the part of the island east of the town of Nantucket. For that part of the island west of the town and for the islands near by, points were furnished by Subassistant Marr. Field operations were closed November 28.

The statistics are:

Miles of shore line surveyed	107
Miles of creeks and ponds	4
Miles of railroads and streets	14

Early in December Mr. Taney was ordered to join the party of Assistant Sinclair for duty on the coast of Louisiana. Reference to this service will be found under a heading in Section VIII.

Topographical resurveys of the shore-lines of Vineyard Sound, Massachusetts.—Upon reporting for duty under instructions to Assistant Henry L. Whiting soon after the beginning of the fiscal year, Assistant W. Irving Vinal was assigned to the immediate charge of the topographical resurvey of part of the shore-line and details adjacent of Martha's Vineyard Island.

The resurvey was mainly directed to those portions of the island where marked changes have taken place during recent years. It included the eastern and western shores of Cotamy Bay and Edgartown Harbor, and extended thence westward and northward along the coast, taking in Cottage City and Vineyard Haven, and terminating at the entrance into Chappaquansett or Tashmoo Pond.

At Cotamy Bay a junction was made with Assistant Whiting's resurvey of 1886. Edgartown is the oldest settlement on the island, dating back to 1642. Vineyard Haven is the most noted roadstead for coasting vessels on the Atlantic coast, and affords perfect protection except in northeast gales. Cottage City occupies the whole of East Chop. It has grown up within recent years, and now includes the settlements or summer resorts of Oak Bluffs, Camp Grounds, Vineyard Highlands, Eastville, and Lagoon Heights.

Mr. Vinal gives in his descriptive report, which he has sent to the archives, many details of interest with regard to the geological formations on the island, its topographical features, means of transportation, etc. He closed field operations November 10, 1887. The statistics of his survey are:

Miles of shore-line surveyed	42
Miles of roads, streets, and railroads surveyed	95
Miles surveyed of creeks, ponds, and ditches	12
Area (approximate) of survey, in square miles	10

During the winter Mr. Vinal was engaged in office-work, completing his field sheets and reports. After reporting in person for duty at the office he was assigned to service in the Drawing Division, and during part of the time was occupied in arranging and cataloguing the miscellaneous papers of that Division. Upon being relieved from office duty he was instructed to report by letter to Assistant Whiting for duty under his direction on the coast of Massachusetts, and on the 18th of June he organized his party at Wood's Holl, Massachusetts, and took up a shore-line resurvey of Martha's Vineyard Sound in that vicinity and to the northward. For this resurvey the topographical features are to be shown in minute detail, the scale being 1–5000. Further mention of its progress will be made in the next Annual Report.

Off-shore soundings between Montauk Point and Phelps Bank.—For the further development of the configuration of the sea-bottom between Phelps Bank and Montauk Point, Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, having organized his party aboard the steamer

Blake, left Boston July 7, and proceeded under instructions to run lines of off-shore soundings about five miles apart between the localities named.

During the first part of the season fogs prevailed almost continuously, so that not unfrequently lines of sounding started with the most favorable weather would have to be abandoned in a few hours. The work was pushed at every opportunity, however, and on August 21 was completed.

The statistics are:

Number of positions occupied	129
Number of miles of soundings	1,786
Total number of soundings	1,386

Under a subsequent heading in this section will be found a notice of Lieutenant Pillsbury's observations of currents in the approaches to New York Harbor, and under headings in Sections V and VI reports of other hydrographic work executed by him.

Hydrographic resurveys in Vineyard Sound and in the channels and harbors adjacent.—Under instructions issued about the middle of June, 1887, Lieut. C. P. Perkins, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner *Eagre*, took up the resurvey of Vineyard Sound and adjacent waters soon after the beginning of the fiscal year.

His work was laid out on four projections: one of Vineyard Sound on a scale of 1–20000, one to the east of the island of Martha's Vineyard on a scale of 1–10000, one of Robinson's Holl on 1–10000, and one of Wood's Holl on 1–5000.

A descriptive report has been submitted by Lieutenant Perkins for file in the archives with his hydrographic sheets. In this report are given many details in regard to the channels and harbors included in the area under survey. He observes that the channel through the sound carries no less than eight fathoms, and that through Quick's Holl six fathoms. Robinson's Holl is impracticable, and Wood's Holl dangerous, except for small craft. He found the tides in the sound very complex and much influenced by the wind. A determination of the zeros of the several tide-gauges was made, and all were referred to the lowest plane, that at Menemsha Bight.

All known shoals and dangers were carefully developed; among these, Squash Meadow Shoals, Old Man Rock, Devil's Bridge, and Sow and Pig's Reef. Information having been received at the Office through the Light-House Board of the existence of an uncharted ledge off the West Chop Light-house, an examination of the locality by Lieutenant Perkins led to the development of two dangers to navigation to the north and northeast of that Light-house; a rocky shoal-patch having over it a least depth of seven feet, and a small rocky shoal with a least depth over it of sixteen and one-half feet. Warning of the dangers was immediately given by the publication of Notice to Mariners No. 93.

Lieutenant Perkins had the aid of Ensigns H. W. Harrison, N. J. L. T. Halpine, Baine C. Dent, and Franklin Swift, U. S. N.

He reports the following statistics for the season, which closed November 10:

Miles of sounding lines run	2,086
Number of soundings	107,531

During the winter Lieutenant Perkins was engaged in preparing his records and hydrographic sheets for transmission to the Office, and had charge of the vessels of the Survey that were laid up in New York Harbor.

In January, 1888, he was directed to make an examination of certain lumps that had formed at the inner end of Gedney's Channel, having less depth of water over them than were found in the survey of 1885. The results of this examination were published in Notice to Mariners No. 99.

On February 28, 1888, Lieutenant Perkins was detached from duty on the Survey.

Offshore and inshore hydrography of the approaches to the western end of Vineyard Sound, to Buzzard's and Narragansett Bays, and to the eastern end of Long Island Sound.—After refitting the steamer *Bache* at New York, her commander, Lieut. J. F. Moser, U. S. N., Assistant Coast and Geodetic Survey, left that port just before the beginning of the fiscal year to take up a hydrographic survey off the coasts of Massachusetts and Rhode Island, specially directed to the development, by close resurvey, of the approaches to the western end of Vineyard Sound, to Buzzard's and Narragansett Bays, and to the eastern entrance to Long Island Sound.

Arriving on the field of work July 4, active operations were begun the next day. The scheme of work was laid out on a scale of 1–10000 for the inshore and 1–40000 for the off-shore hydrography, and included in its limits the waters between Block Island and Point Judith, thence along the coast of Rhode Island and Massachusetts to Gooseberry Neck; thence to Cuttyhunk, Gay Head, and No Man's Land, and seaward as far as a line from Block Island Southeast Light to Davis's New South Shoal Light-ship, and as much beyond this line as would include the twenty-fathom curve.

In executing the hydrography the ten-fathom curve was developed by normal lines, seven to the mile, and crossed by lines, five to the mile, except in the vicinity of Westport, where the ten fathom curve is at such a distance off shore that this system was only carried to the eight-fathom curve. The off-shore work, on a scale of 1–40000, was lapped over the 1–10000 work, and consisted of a series of lines north and south, one-half a mile apart, for a distance of about six miles from shore, and thence seaward one mile apart. This system was crossed by lines east and west, beginning near the shore, one-half mile apart, and after continuing this system for about six miles the distance was increased gradually until the outer seaward lines were one and one-half miles apart.

This was the general system of execution; such deviations were made at different points as the nature of the work required. Where the ten-fathom curve impinged upon the shore the inshore system was carried beyond to a distance of about three-fourths of a mile.

As the work was a resurvey, the shoals and ledges already charted were carefully redeveloped, and great attention was paid to the soundings to note any irregularities of bottom, which, when found, were re-examined.

The soundings being all on an exposed rocky coast, many difficulties were encountered and no little anxiety felt at times in running the boat-lines on account of the continual swell breaking over the rocks and ledges, the prevailing winds during summer blowing on shore and setting in a heavy sea. Fogs retarded the work. During the month of September, when the sea was unusually quiet, no work could be done for a long period on account of a dense smoky atmosphere which enveloped the whole coast, rendering objects invisible at a short distance. Lieutenant Moser states that on several ledges now charted less water was found than previously recorded, and a number of uncharted rocks and ledges were developed. In regard to these his reports give full details. No opportunity was lost of consulting local authorities—pilots and especially fishermen—whose knowledge of rocks is apt to be exceedingly minute.

He recommends a buoy to mark the Narrow River Ledge as a guide to vessels running from Newport to Narragansett Pier and to vessels beating up to the western passage of Narragansett Bay. Also one to mark the seaward end of the Cuttywaugh Ledge south of Quicksand Hill. This buoy would serve not only as a warning to vessels beating up to this ledge, but as a general guide to keep vessels from approaching this dangerous shore. He suggests also for consideration, the placing of a buoy to mark the four-fathom ledge to the eastward of the Hen and Chickens Light-ship. This buoy would be useful to vessels during heavy weather.

An error in the position of Vineyard Sound Light-vessel, as shown on the charts, having been found, its correct position was determined by Lieutenant Moser, and announcement made in Notice to Mariners No. 95.

He has transmitted to the Office, for file with his hydrographic sheets, two descriptive reports, covering all the topics suggested for consideration in the instructions and memoranda for such reports. (Appendix No. 11, 1887.)

The following officers were attached to the party: Lieut. E. E. Wright, U. S. N.; Ensigns H. A. Field, W. O. Hulme, H. P. Jones, and H. E. Parmenter, U. S. N.

For the season, which closed early in November, the statistics are:

Miles (nautical) run in sounding	2,421
Number of angles measured	17,191
Number of soundings	60,113

After returning to New York the *Bache* was prepared for hydrographic work on the Florida coast. Duty assigned to Lieutenant Moser on that coast will be referred to under a heading in Section VI.

Hydrographic resurveys in Vineyard and Nantucket Sounds.—Under instructions dated April 27, 1888, Lieut. S. C. Paine, U. S. N., Assistant Coast and Geodetic Survey, proceeded to the Navy-yard, New York, took command of the schooner *Eagre*, and put her in condition for active service.

Toward the end of May he arrived with the *Eagre* at Wood's Holl, Massachusetts, and began the hydrographic surveys in Vineyard and Nantucket Sounds, indicated as his work for the season in detailed instructions from the Hydrographic Inspector. These surveys were in progress at the close of the fiscal year, and further mention of them will be made in the next annual report.

Hydrographic examinations for the Coast Pilot on the southern coast of Massachusetts, including Nantucket and Vineyard Sounds and Buzzard's Bay.—In order to test sailing lines and decide a number of questions which had arisen in connection with the preparation of the Atlantic Coast Pilot, Lieut. G. H. Peters, U. S. N., Assistant, was instructed towards the end of May, 1888, to take command of the steamer *Daisy* and make hydrographic examinations of the harbors in Vineyard and Nantucket Sounds and neighboring waters.

Lieutenant Peters observes that these sounds form a great highway of commerce, being said to rank in this respect next after the English Channel and the Straits of Gibraltar. The adjacent harbors and anchorages have thus an importance resulting from their location far beyond that arising from the local carrying trade. In planning and carrying out the work this fact was given due consideration.

With regard to Buzzard's Bay he remarks that it is mainly important, commercially, as an approach to New Bedford and to Wareham, but the minor harbors along the shores of the bay received all the attention necessary. Many changes having occurred since the survey of 1845, a resurvey of the bay is exceedingly desirable.

Advantage was taken of a favorable opportunity to extend the examinations into Narragansett Bay. Due effort was made throughout the work to make available the local knowledge of persons familiar with the waters examined, and to verify data previously obtained by means of the general forms of Coast Pilot interrogatories.

Mr. John Ross, of the Coast Pilot office party, served during the season and rendered valuable assistance.

On July 7, in accordance with instructions, the *Daisy* was turned over to Ensign Franklin Swift, U. S. N., and, field operations having been closed, the party of Lieutenant Peters returned to the Office to resume their regular duties.

SECTION II.

CONNECTICUT, NEW YORK, NEW JERSEY, PENNSYLVANIA, AND DELAWARE, INCLUDING COAST, BAYS, AND RIVERS. (SKETCHES NOS. 1, 3, 4, 17, AND 18.)

Hydrographic examinations in Stonington Harbor, Connecticut.—A letter having been received from the general manager of the Stonington line of steamers, referring to a supposed shoaling in the approaches to Stonington Harbor, Lieut. Sumner C. Paine, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner *Eagre*, was instructed to make an examination of the locality with special reference to the shoals known as Noyes Rocks and the Middle Ground.

This duty was accomplished between May 22 and 29, after which Lieutenant Paine proceeded to Wood's Holl, Massachusetts, and took up the regular work of the season.

Examination of coast currents in the approaches to New York Harbor.—In connection with the off-shore soundings between Phelps Bank and Montauk Point, referred to under a previous heading in this section, Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer *Blake*, took up, under instructions, an examination of the currents in the vicinity of the entrances to Vineyard, Block Island, and Long Island Sounds, and also between Fire Island and Barnegat.

Before beginning to observe, he deemed it expedient to gather as much testimony as possible respecting these currents from the masters of ocean steamers bound to New York and from pilots and fishermen, etc., so as to get a knowledge of the usual routes of vessels regularly approaching the port. This decision was based upon the experience he had gained in his recent deep-sea sounding work from Montauk to beyond Nantucket Shoals, where he had found a considerable current setting on and off shore, and surmised that perhaps the currents at this point of the route might be of more influence in deflecting vessels from their courses than those to the westward.

The testimony of the ocean steamship captains was, generally, that the allowances they made for currents depended upon the winds. With a wind on shore they allowed a trifle off shore on their courses. Two or three captains made allowances for tide, a trifle off shore for the flood and on shore for the ebb. Fishermen, as a rule, had not remarked a current, but of course made an allowance for leeway. Upon this testimony, with his own experience, Lieutenant Pillsbury decided to multiply current stations in the vicinity of the openings to Vineyard Sound, Block Island, and Long Island Sounds, and then observe the currents between Fire Island and Barnegat.

He found that the currents at the nine stations first occupied in the vicinity of No Man's Land, Block Island, and Montauk Point were much stronger than those between Fire Island and Barnegat. This he thinks would naturally be caused by the larger basins to be filled and emptied in the sounds and bays of southern Massachusetts, Rhode Island, and Connecticut.

On all the stations there was a marked interference with the direction and velocity of the current, the cause of a part of which seems to be a variation in the strength of the tidal flow, which is stronger at spring tides than at neaps, and stronger after the highest declination of the moon than it is after zero declination. But until much more extended series of observations can be made, and under conditions more varied, the laws governing the action of these currents can not be fully developed.

Lieutenant Pillsbury's conclusions for the practical purposes of navigation were embodied in a Notice to Mariners (No. 97). They are substantially as follows:

That off the entrances to Vineyard, Block Island, and Long Island Sounds there is a tidal current which sets on shore with the flood and off shore with the ebb, its direction changing from one to four hours after high and low waters at Newport, Rhode Island.

The velocity is greater at spring-tides than at neaps, varying from two-tenths of a knot to one and a half knots. The direction and velocity of the tidal currents is interfered with by what is probably an inshore current setting to the westward, the influence of which is felt the least the nearer to the shore.

On the track of the European steamers bound to New York, the tidal current is most decided in direction on and off shore at the time of spring-tides. Three days after the highest declination of the moon the counter-current is strongest, setting to the southward and westward. The greatest current found on this track has been about one knot per hour. In allowing for this current, the state of the tides and the position of the moon should be taken into account.

Between Fire Island and Barnegat only a feeble current was found, generally but two or three tenths of a knot, and at the time of spring-tides increasing to about one-half knot.

Lieutenant Pillsbury, in the closing part of his report, discusses the question as to the direct effect of wind on the tide-water in forming a current, and adduces evidence tending to show that short winds do not produce marked currents in deep water. On the question of the effect of long continued winds, like the trades, he reserves his opinion till he has obtained further data bearing upon the subject.

His explorations of the Gulf Stream currents, which were continued during the following winter and spring, are the subject of an abstract under the heading of Section VI.

Triangulation on the south coast of Long Island and determination of the geographical position of Light-houses on the coasts of Connecticut and Rhode Island.—The triangulation required for the shore-line resurvey of the bays on the south coast of Long Island having been assigned to Assistant A. T. Mosman, as also the determination in geographical position of some light-houses on the coasts of Rhode Island and Connecticut, by instructions dated April 30, 1888, Mr. Mosman organized his party early in May at Centre Moriches, Long Island, and began a search for two of the old stations from which as a base to make a triangulation of Moriches Bay.

Upon the completion of this portion of the survey towards the end of June, the party was transferred to Shinnecock Bay. The interval between their arrival and the end of the fiscal year was spent in erecting signals and marking stations on the bay, and beyond it to the eastward as far as Bridgehampton, and on the 30th observations were begun at Shinnecock Light-house.

Up to this date Mr. E. E. Torrey served as recorder in the party, and was then transferred to the party of Assistant Fairfield, in Indiana.

Further account of Mr Mosman's progress is necessarily deferred till the next annual report.

The statistics to June 30th are:

Number of signal poles erected	20
Number of stations occupied for horizontal measures	12
Number of geographical positions determined	27
Area of triangulation, in square statute miles	59

Reference is made under the head of Section XIII to the extension westward of the transcontinental triangulation in Kentucky and Ohio, conducted by Mr. Mosman earlier in the fiscal year.

Resurvey of shore-line on Long Island from Hog Neck to Riverhead, including the shore-line of Noyack, Little Peconic, and Great Peconic Bays; also of the ocean shore from Amagansett westward.— Soon after the beginning of the fiscal year, Assistant C. T. Iardella proceeded under instructions to Sag Harbor, Long Island, where, having organized his party, he took up a resurvey of the shore-line of Noyack Bay, from the limits of the work of the previous season executed by Assistant Charles Hosmer. Proceeding westward he continued the shore-line resurvey of Little Peconic and Great Peconic Bays, carrying the work as far as Riverhead on the west, and thence eastward to include Robbins's Island, Cutchogue Harbor, and the shore-line of Little Hog Neck.

The area surveyed presents no features of special topographical interest. The shores are generally long sand beaches dotted with small bowlders. There are two large bowlders which are visible at quite a distance—one on the southeast end of Robbins's Island, distant four hundred and fifty feet from high-water mark; the other, five hundred and twenty-five feet from high-water mark, is nearly abreast of New Suffolk, and is known as Black Fish Rock; it stands about ten feet out of water at high tide, and can be seen plainly for nearly half a mile by vessels running into the harbor. A short distance from this rock is another, just bare at low tide, where large quantities of black-fish are caught.

On October 31 field operations were closed. The statistics of the topography, which was executed on a scale of 1–10000, are as follows:

Miles of shore-line surveyed	70
Miles of marsh-line surveyed	21
Miles of shore-line of creeks and ponds	18
Miles of roads	5
Area of survey, in square miles	9

During the winter Mr. Iardella was engaged in duty at the Office, and towards the end of April was directed to organize his party for surveying the shore-line and adjacent topography at the east end of Long Island, and the ocean shore-line from Amagansett westward.

On the 9th of May he reached Sag Harbor, Long Island, where he organized his party, and on the 14th began a resurvey of the inner shore-line of Sag Harbor Cove. Having finished this work May 22, he took up the resurvey of the inner shore-line of Northwest Harbor and completed it June 6.

Between that date and the end of the fiscal year the following surveys were made: the inner shore-line of Coccles Bay, the inner shore-line of West Bay Harbor, the outer shore or beach-line from Montauk Point to Amagansett Life-Saving Station, and the inner shore-line of Acabomack Bay. The topographical sheets upon which this work was done were sheets that had been partially completed by Assistant Hosmer in 1882, 1883, 1884.

Mr. Iardella has included in his report descriptions of the several harbors within the limits of his work, which was executed on a scale of 1–1000.

For the fiscal year the statistics are:

Topography:

Area surveyed, in square statute miles	19
Length of general coast, in statute miles	121
Length of shore-line of creeks, in statute miles	9
Length of shore-line of ponds, in statute miles	10
Length of roads, in statute miles	7
Topographical sheets finished (scale 1–10000)	9

Topographic resurvey on the south coast of Long Island from near Babylon to the westward, and soundings in Fire Island Inlet.—In order to fill a gap in the topographical resurvey of the south coast of Long Island, and to obtain additional soundings needed at Fire Island Inlet, Assistant W. H. Dennis organized a party, under instructions, dated June 25, 1887, and began field-work July 1, near Babylon, Long Island.

The topography was carried from the shore back to the line of the Long Island Railroad, from Babylon to the westward, to and including Baldwin. The whole distance was almost a continuous village.

On September 1, Mr. Dennis proceeded to Fire Island, made an examination of the bar at the inlet, and resurveyed the shore-line, taking also such soundings as were needed. He then resumed his topographical resurvey, and on the 7th of November completed it.

At Flushing Bay, Long Island, and at Long Branch, N. J., he delineated on plane-table sheets the newly constructed piers.

The statistics of the season are:

Miles of roads surveyed	147
Miles of creeks surveyed	79
Miles of marsh-line surveyed	54
Area of topography, in square miles	34

Upon leaving the field, Mr. Dennis was ordered to complete the inking of his plane-table sheets, and on December 15 was directed to report to the Assistant in charge of Office and Topography for duty as chief of the Division of Charts.

Physical hydrography of New York Bay and Harbor.—The under-run of the Hudson River; its relation to New York Bar.—In continuation of his investigations relating to the physical hydrography of New York Bay and Harbor, Assistant Henry Mitchell has submitted a special report upon the under-run of the Hudson River, its relation to New York Bar, and upon the courses of the Hudson tides through New York Harbor. As the Annual Report for 1887 had not gone to press at the time this paper of Mr. Mitchell's was presented, it was prepared for publication as Appendix No. 15 of that report, and a synopsis of it given under the heading of special scientific work in Part I. It is only necessary, therefore, to refer to it here as bringing the subject of these investigations nearly to a close, leaving yet to be discussed the results of the physical surveys made by Assistant Marindin in New York Harbor in 1887.

Continuation of physical hydrographic surveys in New York Bay and Harbor.—At the beginning of the fiscal year the physical hydrographic parties in charge of Assistant Henry L. Marindin had been organized on board the schooners *Ready* and *Palinurus*, with two steam-launches attached, and were engaged in making observations of the currents in the channels over Sandy Hook Bar, under instructions dated July 5, 1887. A report of the work accomplished by Mr. Marindin's party before the beginning of the fiscal year was given in the last Annual Report, with statistics up to June 30, 1887.

The plan of work has been fully set forth in a memorandum prepared by Assistant Henry Mitchell. It was desired to have such observations of the currents over the bar at Sandy Hook made as would serve to derive the "Constants of Scour," with their co-efficients, and ascertain the "control" of the several channels. In carrying out this plan, the velocities and directions of the currents in the channel cross-sections were to be observed, paying most attention to the currents flowing along the bottom. The instruments which had at first been used for this purpose were found to have certain objectionable features, which ultimately led to their abandonment and to the adoption, after several trials, of the new velocity and direction meters designed by Messrs. Ritchie and Haskell.

These new meters combine, in one instrument, a means of registering by electricity the velocity of a current and the direction of its flow. The registration is made on the vessel's deck without removing the instrument from the water.

While following the memorandum as closely as possible, transverse curves of velocities were obtained at the surface, mid-depth, and bottom in the fourteen-feet channel in the East, in the Swash, and in the Main Ship Channels. These determinations were repeated wherever necessary, and the channels were also occupied longitudinally in order to ascertain the relation, if any, of velocity to profile of section.

During the progress of the work at Sandy Hook, Mr. Marindin was directed to communicate with Subassistant McGrath, who was then engaged in running a line of leveling of precision between the tidal stations in New York Bay and Harbor, and to make arrangements to be present when the reference of the tide-gauge and staff was to be made to the bench-marks at the Horseshoe, Sandy Hook. This duty was performed by Messrs. Marindin and McGrath early in August.

Observations of the tides in connection with those at the Sandy Hook station were continued during the season at the tide-gauge established on the steam-boat wharf, on Bath, Long Island. Data of a trustworthy character were thus secured for a discussion of the results of the work.

On the 10th of August, in anticipation of the speedy close of the survey in New York Harbor, and of the transfer of his party to Cape Cod, Mr. Marindin laid up the *Palinurus* and the launch accompanying and devoted a few days, with reduced force, to re-rating the current meters in the slack-water pond at West Brighton, Staten Island, so as to ascertain the change of rate, if any, due to the use of the instruments during the months preceding.

The *Ready*, with the remaining launch, was then laid up, and on the 18th of August field operations were closed.

Statistics of Mr. Marindin's work in New York Harbor are included in those of his work off Cape Cod Peninsula, a report of which has been given under a heading in Section I. With his progress report of the New York Harbor work he has furnished a sketch showing the location of the current stations, the lines of cross-sections sounded, and the location of the tide-gauges.

Geodetic leveling for the connection of the tide-gauges and bench-marks in New York Bay and Harbor and vicinity.—Reference was made in the last annual report to the transfer of the charge of geodetic leveling operations on New York Bay and Harbor and neighboring localities to Subassistant J. E. McGrath on June 7, 1887. At that time the party was quartered at Clifton, Staten Island, and was engaged in running lines connecting the tide-gauges and tidal bench-marks on the north shore of Staten Island with the main line of levels which was to extend from Sandy Hook, New Jersey, to Willets Point, East River, New York, crossing from Staten Island to Long Island at the Narrows.

From a bench-mark in the secondary line of levels which was run around the north shore of Staten Island, a branch line was started which crossed the Kill van Kull at New Brighton, Staten Island, and connected with the tide-gauge and tidal bench-mark of 1886 at Constable's Hook, New Jersey. From a bench-mark on the Constable's Hook line, connection was made by way of Bergen Neck with the lower end of Jersey City and with the tide-gauge established in 1886 on the center of the bridge of the New Jersey Central Railroad, which crosses the Hackensack River near its mouth.

Details of other connections made with tide-gauges and tidal bench-marks established in 1885 and 1886 at points on the shores of the Kill van Kull and of Raritan and Sandy Hook Bays are given by Mr. McGrath in his report. Also of the connections made with several bench-marks of the first section of the transcontinental line of geodetic leveling run by Assistant Braid in 1881 from Sandy Hook toward Hagerstown, Md. Upon the completion of the work in New Jersey, by which trustworthy checks for all of the branch lines of leveling were obtained, the party was removed to New York City and the work begun of connecting the tide-gauges and tidal bench-marks along the Hudson River with the line of precise leveling extending from Sandy Hook to Willets Point. This was satisfactorily accomplished by the 5th of September, whereupon field operations were brought to a close, and Mr. McGrath proceeded under instructions to the Office to compute the results of his observations.

A tabular statement accompanies Mr. McGrath's report, showing the points connected, the distances run, and the probable error per kilometer. He observes that the great heat of the season delayed progress on some of the routes followed. Along the white sandy road-bed of the New York and Long Branch Railroad the advance was necessarily slow, as on account of the unusual refraction the length of sights on most of the working days between the hours of 9 a. m. and 3.30 p. m. had to be reduced to one-third or even one-fourth of the distances obtained under more favorable circumstances. The number of water crossings also led to delay; these were the Narrows (with a width of 1,420 meters), the Kill van Kull, the Hackensack River, the Arthur Kill (crossed twice), Raritan Bay, and the Shrewsbury River.

Mr. John Nelson was attached to the party as Aid, and rendered service which for faithfulness and efficiency is highly commended. Mr. F. A. Young served acceptably as recorder.

Duty subsequently assigned to Mr. McGrath is referred to under a heading in Section VIII.

Continuation of tidal record from automatic tide-gauge at Sandy Hook, New Jersey.—The present series of tidal observations at the station established for a self-registering tide-gauge, December 1, 1886, at Sandy Hook, was continued successfully throughout the year. Mr. A. J. Brennan remained in charge until April 16, 1888, when he was relieved by Mr. J. G. Spaulding, an observer of great experience and tried fidelity, who had just completed an eighteen-year series at an automatic tidal station in Penobscot Bay.

Reconnaissance for connecting the triangulation in the southern part of the State of Pennsylvania with the primary triangulation in Maryland.—A preliminary reconnaissance had been undertaken under instructions by Prof. Louis H. Barnard, Acting Assistant, soon after the beginning of the fiscal year, looking to a connection between the triangulation in Pennsylvania to the south and west of Harrisburgh and Gettysburgh with the primary triangulation in western Maryland.

Professor Barnard had outlined a connection between these triangulations as far as it could be done without erecting any signals, and with an instrumental outfit consisting of a draw telescope, azimuth compass, and azimuth barometer. In order to determine more definitely the conditions upon which the proposed connection could be economically and satisfactorily made, Assistant Joseph Hergesheimer was instructed on the 28th of July to take charge of the party, relieving Professor Barnard.

Mr. Hergesheimer, finding it expedient to go over the whole ground, began his reconnaissance from the line Round Top-Pulpit Rock in Pennsylvania. Having rebuilt the tripod and scaffold at Round Top and the tripod at Pulpit Rock, he opened the line from the last-named station to Sugar Loaf. While engaged at Pulpit Rock, Professor Barnard, who had remained with the party, was sent to Piney Mountain to put that signal in order for observing. The rest of the season Mr. Hergesheimer spent in visiting the points Clark's Knob, Fairview, Maryland Heights, Sugar Loaf, and Mount Quirauk to verify the intervisibility of the points, measure reconnaissance angles, and note the condition of the station marks. All of these stations, except the first named, are in Maryland.

Progress was greatly retarded by continuous thick, hazy weather, there having been but five days of fairly good seeing during the season, which closed September 19. The scheme of triangulation submitted presents a satisfactory connection between the Pennsylvania and Maryland systems, Mount Quirauk, just south of the Pennsylvania boundary, being the central point from which the seven other stations of the scheme are all visible.

During the winter and spring, Assistant Hergesheimer was assigned to duty on the west coast of Florida, reference to which will be made under a heading in Section VI.

Physical hydrography.—Formation and movement of ice in Delaware Bay and River, as observed during the winter of 1887–'88.—It appears from the third annual report submitted by Assistant Spencer C. McCorkle, in regard to the formation and movement of ice in Delaware River and Bay during the winter of 1887–'88, that the delays and dangers to navigation from this source were of shorter duration and less in extent than in the previous winter; that they are gradually diminishing, and that the works of construction intended to deepen and widen the river channels tend every year to make it easier for vessels to pass up and down the river during the prevalence of ice.

For the purposes of his observations, which were undertaken in pursuance of instructions issued October 18, 1887, Mr. McCorkle divided the river and bay into three sections, the first extending from Bridesburgh to Chester; the second from Chester to New Castle, and the third from New Castle to Cape Henlopen.

In all of these sections were included observations made at Mr. McCorkle's request by the masters of city ice-boats, and by the captains of the Winsor line of Philadelphia and Boston steam-ships.

In the first section were included also observations made by the Signal Service, U. S. Army, in Philadelphia, by the masters of the Philadelphia and Reading line of steam colliers, and by the light-house keepers near the Horseshoe, at the mouth of the Schuylkill River, at Billingsport, and at Schooner Ledge.

In the second section, observations were made also by the keepers of light-houses at or near Cherry Island Flats and Deep Water Point, and in the third section by the light-house keepers at New Castle, Finn's Point, Reedy Island, Ship John Shoal, Cross Ledge Shoal, and Brandywine Shoal; also by special observers at Fort Delaware and at Delaware Breakwater. Mr. McCorkle made observations personally in each of the sections.

Ice began to form in the river on the 28th of December, but did not become much of an obstruction to navigation until January 23. Between that date and February 20 there was at times heavy ice in the river and bay. On February 20 the city ice-boats were laid up, and there was no ice of note after that date.

In the section of the river from Bridesburgh to Chester, Mr. McCorkle observed that during the whole period of freezing weather, with scarcely an exception, there was a clear streak of water on the Pennsylvania shore, opposite the dike at Fisher's Point. As the ice was solid above and below, this open water was doubtless due to the action of the dike in causing a greater rapidity of the ebb current on the Pennsylvania shore. The channel to the eastward of Petty's Island was solid up to about February 20. From a short distance above the foot of Petty's Island to Gloucester the ice was nearly always in motion, and the city front was generally clear of ice. The exceptions were very few.

From Gloucester to Chester the greatest obstructions were in the Horseshoe, as in previous years, and in the vicinity of Billingsport, where the channel decreases in width from about 3,300 feet above to about 750 feet at the head of Tinicum Island, and to about 2,100 feet below. The engineer in charge of the improvements of the river suggests that the dike from Hog Island to Maiden Island will probably have the effect of removing a portion of the head of Tinicum Island, and thereby increase the width of the channel.

In the second section, from Chester to New Castle, there were only parts of days when the motion of the ice was suspended. The greatest difficulty found in this section exists chiefly in the vicinity of Deep Water Point, where the river narrows and forms two channels on either side of Cherry Island Flats. At Marcus Hook and New Castle, the ice-harbors afford good protection to vessels entering, but at New Castle the capacity of the harbor is greatly lessened by shoal water. Mr. McCorkle is of opinion that the United States pier at this place might be extended with good results, and that it would be of much advantage to have the light-house depot established here.

In the third section, from New Castle to Cape Henlopen, the chief obstructions from ice occur in the eastern (or Ship) channel, above Fort Delaware, and in the vicinity of the Ship John Shoal. The ebb passes out through the western channel, where the ice during the season was in constant motion, while in the eastern channel the aid of the ice-boats was frequently required, not, however, for full-powered steam-ships.

Below Fort Delaware, to the capes, the ice was constantly in motion, and though unusually heavy, steam-ships were constantly moving up and down. At Delaware Breakwater the harbor was full of ice between January 22 and January 29, but no damage to vessels was reported.

Mr. McCorkle passed down the river on January 20 on a light-draught steamer, and found considerable ice, but it caused little detention. He was informed by the superintendent of the city ice-boats that the ice was at its worst on the 28th, 29th, and 30th of January, and between Chester and Philadelphia. During these days, several vessels were injured by ice, and some of them seriously.

The ice-boats, as well as the large steam-ships, go through the heaviest ice at almost full speed.

Observations for the density and temperature of the water, for temperature of air, and of the tides were made at Delaware Breakwater by an observer of the Philadelphia Maritime Exchange, and at Fort Delaware by William Byrnes, ordnance sergeant, U. S. A. The observations at Fort Delaware seemed to show that very little salt water gets that far up the river, but in order to determine the question, observations should be taken between the middle of August and the middle of September.

Mr. McCorkle acknowledges his indebtedness to Commander John J. Read, U. S. N., Inspector of the Fourth Light-House District, and through him to the Light-House Board, for co-operation in the work at twelve light-house stations on the river and bay. Also to Henry Winsor & Co., of the Philadelphia and Boston Steam-ship Line, who furnished the log-books of their ships for inspection.

To the Director of Public Works of the city, to the superintendent and other officers of the city ice-boats, and to the Philadelphia Maritime Exchange, he expresses his thanks for attentions shown and facilities afforded in prosecuting his work.

Also to Lieut. Col. H. M. Robert, Corps of Engineers, U. S. A., and through him to William Byrnes, ordnance sergeant, U. S. A., who made the observations at Fort Delaware.

The regular duties assigned to Assistant McCorkle in the charge of the Sub-office at Philadelphia during the year, are referred to toward the end of Part II of this volume.

Geodetic operations.—Continuation of reconnaissance and triangulation in the southern part of the State of New Jersey.—The geodetic operations referred to in the last annual report as in progress in southwestern New Jersey, under the direction of Prof. E. A. Bowser, Acting Assistant, were continued after the beginning of the fiscal year until September 26, 1887. On the 1st of July, but a few days' observations were needed to complete the occupation of station Richland, which had been begun on June 2.

On July 13, Richland station having been finished, the party and instruments were transferred to Newfield, a point about three and a half miles in a northerly direction from Vineland, N. J. The signals at Hammonton and Kellogg were re-adjusted; a signal was erected at Richland; lines were run from Newfield to Hammonton, Williamstown, and Bridgeton for locating vistas, and these vistas were opened. At Bridgeton a signal was put up fifty feet in height, and the signal at Williamstown was raised eight feet. A reconnaissance which had been partly executed at the outset of the season was then resumed, its object being to determine a station twelve or fifteen miles to the west of Newfield, that would see Bridgeton, Newfield, and Williamstown, and that would also command a good view of the country to the north, west, and south.

Colson station was finally selected, and a signal erected there seventy-two feet high. Measurements of horizontal angles were in the mean time continued at Newfield whenever the weather would permit.

On August 30, a granite monument was set to mark the station point. This monument is four feet long, dressed six inches square at one end for a length of six inches, and is set in hydraulic cement to within six inches of the top. It has the letters U. S. cut in each of the four faces, and a triangle on top.

Upon the completion of the observations at Newfield toward the end of September, field-work was discontinued for the season.

Professor Bowser reports that the reconnaissance for the selection of stations in the southwestern part of the State is very difficult, owing to the exceeding flatness of the country and the extensive areas of thick, tall timber, much of it being ninety and one hundred feet high. High scaffolds will have to be built when stations Williamstown, Bridgeton, and Colson are occupied, and lines of sight opened through the intervening woods. With a more liberal appropriation for State surveys, the progress of the work would be more rapid and its cost in the end be less.

Between the beginning of the fiscal year and the close of the season there were taken twenty-eight sets of observations upon four primary points, and two sets upon two tertiary points at station Richland. Sixty-one sets of observations were taken at station Newfield upon six primary points, and twenty-two sets upon twelve tertiary points. All of the stations occupied for observations of horizontal angles have been carefully marked.

SECTION III.

MARYLAND, DISTRICT OF COLUMBIA, VIRGINIA, AND WEST VIRGINIA, INCLUDING BAYS, SEA-PORTS, AND RIVERS. (SKETCHES Nos. 1, 4, 5, 15, 17, and 18.)

Determinations of gravity at the Smithsonian Institution, Washington, in connection with similar determinations in the Hawaiian Islands and in California.—A full abstract is given under the heading "Special operations," and mention made under a heading in Section X of the gravity work executed during the fiscal year by Subassistant E. D. Preston, at the Hawaiian Islands and in California, the work at the Hawaiian Islands having been done in pursuance of a special assignment to this duty, made at the request of the Hawaiian Government and by direction of the Secretary of the Treasury.

Upon the completion of these observations at the stations in California, Mr. Preston proceeded under instructions to Washington, and early in December made preparations for a series of comparative determinations of gravity by pendulum experiments at the station at the Smithsonian Institution. In this work, which was executed between December 9 and 22, 1887, he had the aid of Assistant J. B. Baylor.

Magnetic determinations (annual) at a station on Capitol Hill, Washington, D. C.—The reasons which led to the abandonment of the locality occupied since 1877 on Capitol Hill, Washington, for an annual determination of the magnetic elements, were stated in the last annual report. At the new station, selected, under the direction of Assistant Schott, in the grounds immediately south of the Coast and Geodetic Survey Office, determinations of the magnetic dip, declination, and horizontal intensity were made by Assistant J. B. Baylor on July 28, 29, and 30, 1887, the direction of the true meridian having been previously obtained by observations on the sun on three days.

To secure this point, it was marked by a solid white-oak post, driven flush with the ground, a copper tack being driven into its center.

The position thus marked is within a few meters of the magnetic station occupied by Mr. Schott in 1856.

On June 19 and 20, 1888, the station was re-occupied by Mr. Baylor. The results show that the observations are normal.

Continuation of the detailed topographical survey of the District of Columbia.—At the beginning of the fiscal year, the field-work in continuation of the detailed topographical survey of the District of Columbia was divided between two parties, one of these being placed in charge of Assistant John W. Donn, who had conducted the survey from the outset, and the charge of the other being assigned to Assistant W. C. Hodgkins.

Mr. Donn began work July 1, 1887, in the northeastern section of the District, the triangulation points upon which his survey in that locality depended being Bunker Hill, Hoover's Hill, and Reform School. Some new points had to be determined before the plane-table work could proceed to advantage. On July 9 the topography was begun, and as the summer and fall were favorable to progress, all of the open ground was completed before the trees were cleared of leaves, not only in the section in which the season's work was begun, but also in that to which the party was transferred later in the season, on the eastern branch of the Potomac.

There were several large areas of woods within the limits of the two sheets. One area of one hundred acres was exceedingly difficult, having been abandoned at the close of the civil war to nature, which covered it with thickets of black pine, cedar, and bramble. In November it became practicable to carry the work through this region. A still larger body of woods on the west side of the Anacostia River could not be reached before field operations were necessarily suspended. During their progress, the preparation of section drawings for the photolithographer was continued by Mr. Donn, and by his Aid, Mr. J. A. Flemer, at every favorable opportunity. Two of these sections were finished, and about three-fourths of a third section.

In reference to the statistics of his survey, Mr. Donn observes that while he transmits them on the usual forms he includes an item which he regards as the most important feature in large-scale work as well as the most difficult, namely, the lengths of contour lines instrumentally determined. For this he submits the following statement:

From the beginning to the end of the season, July 1 to December 13, one hundred and twenty-five and six-tenths working days, a contoured area of one thousand seven hundred and eighty-eight acres was delineated, involving two hundred and thirty-seven miles of contoured lines, an average of one and eighty-eight one-hundredths miles per day. A comparison of this result with the work accomplished during the latter part of the preceding year, when the party was transferred from the western to the eastern division of the district, is as follows: From March 16 to May 9, thirty-eight working days, five hundred and forty-six and five-tenths acres, and seventy-two and two-tenths miles of contour lines, a daily average of one and nine-tenths miles.

Average number of acres completed daily from February, 1881, to May, 1887, was nine and three-tenths acres, at a cost of $1.96 per acre. For the period from July 1, 1887, to December 13, 1887, the average was twelve and six-tenths acres daily, at a cost of $1.12½ per acre. Marshy areas are not included in the estimates of averages, contour work only being considered. These differences in the cost and in the results fairly show the relative difficulties of the work in the two divisions, $1.96 per acre representing the western and $1.12½ the eastern.

For the season which closed December 13, owing to the exhaustion of the appropriation for field-work, the regular statistics reported are:

Signal poles erected for triangulation	3
Number of stations occupied for horizontal measures	3
Geographical position determined	1
Area surveyed, in square statute miles	3.3
Length of shore-line of rivers, in statute miles	8
Length of shore-line of creeks, in statute miles	12
Length of roads, in statute miles	16

The scale of the survey is as heretofore, 1–4800.

During the rest of the fiscal year Mr. Donn was engaged in advancing office-work on the field sheets.

Continuation of the detailed topographical survey of the District of Columbia.—In the preceding paragraphs reference was made to the placing of two topographical parties in the field at the beginning of the fiscal year to continue the detailed survey of the District of Columbia.

The party of Assistant W. C. Hodgkins began work July 1 in the northeastern part of the District, extending from the Brentwood road to the left bank of the Eastern Branch. Operations of a preliminary nature occupied almost entirely the month of July. Lines of levels were run to obtain a sufficient number of bench-marks for ready use in the topography, and additional triangulation points were determined where needed.

Intense heat during July and August somewhat retarded progress; delay was caused also by the necessity of training a new party to the special duties of this detailed survey. The field-work was steadily prosecuted, however, until the exhaustion of the appropriation, in March.

Several quite difficult areas of woods were included in the region surveyed, such as those on the Brentwood and adjoining estates, and Mount Olivet Cemetery and surroundings, especially that portion between Mount Olivet and the Eastern Branch, which is very steep, broken into numerous ravines, and densely wooded.

The marshy tracks above and below Benning's bridge, although admitting of more rapid work than the intricate contouring just mentioned, yet presented some special difficulties owing to the extremely soft character of the mud, especially south of the bridge, where holding ground could hardly be obtained for the plane table, while, on account of the width of the marshes, it was impossible to do all the work from the hard land.

These marshes, Mr. Hodgkins observes, are said to be increasing in elevation by deposit from the stream, especially on the western shore of the branch at a point where the great intercepting sewer empties itself.

Mr. R. E. Nelson, jr., as levelman, and Mr. Eberhard Fordan, as rodman, rendered faithful service.

Topographic and hydrographic resurveys on the eastern shores of Delaware, Maryland, and Virginia.—Under instructions dated August 18, 1887, Assistant D. B. Wainwright took up topographic work which involved a resurvey of the inland waters on the eastern shores of Delaware, Maryland, and Virginia, beginning at Little Assowoman Bay, in Delaware, and extending to and including the upper portion of Chincoteague Bay, in Maryland, the resurvey of Chincoteague Inlet and Bar, and the resurvey of the bays and thoroughfares to a point twenty miles below.

Mr. Wainwright has submitted a descriptive report to accompany the hydrographic sheet showing the results of his resurveys.

With regard to the changes that have taken place at Chincoteague Inlet and vicinity since the survey of 1881, he observes that the bar is somewhat north of its position at that date as shown on the chart published in 1882. It is situated between the point of Fox and Richardson's shoals, which are separated here three-eighths of a mile, and consists of two channels and a middle ground. The channel on the northeast side, adjoining Fox Shoal, has a depth at mean low water of from eight and a half to nine feet. The other, on the southwest side, adjoining Richardson's Shoal, has a depth of seven feet. On the middle ground there is six feet.

The outer edge of the bar, especially near the middle ground, is quite steep, as it rises in a short distance from depths of twelve and fourteen feet to seven and six. The bar is subject to frequent changes laterally, and consequently the buoys do not always show the best water.

It is generally reported that the bar increases in depth to at least one foot after a northwest blow of several days' duration. There are no pilots, as strangers rarely enter the inlet, and the masters of the few small schooners trading in the vicinity keep themselves well informed as to changes in progress.

Mr. Wainwright gives the following local names for insertion on later editions of the charts of that locality: New Inlet, the mouth of the Eastern Channel; Fox Shoal, north side of bar and channel; Richardson's Shoal, south side of bar and channel, and Gunboat Drain, a slough which makes out around the north point of Wallop's Island.

On February 29, 1888, the survey having been finished, Mr. Wainwright was directed to report at the Office for duty in completing his records.

The statistics are:

Number of miles of shore-line surveyed	19
Number of miles of soundings run	487
Number of angles observed	1,851
Number of soundings	26,930

Towards the end of March he was instructed to take up work for the connection of certain detached triangulations on the coast of North Carolina. This service will be referred to under a heading in Section IV.

Completion of the triangulation in the vicinity of Cape Charles, Virginia.—Brief mention was made in the last annual report of the progress of the triangulation of Cape Charles, Virginia, and vicinity, which was in course of execution by Subassistant R. A. Marr under instructions issued towards the close of April, 1887.

On account of the shifting nature of the outside islands, and the changes reported of the inside channels and mud flats, Mr. Marr deemed it advisable to insure permanent points on the main-land for future use by running a double chain of quadrilaterals on the sea-coast.

Some marked changes since the last survey were noted. Cobb Island has made out on the south end, and lost on the middle and upper portions; Bone and Wreck Islands are connected, the channel which divided them having filled without leaving an indentation in the sand ridge to show where it had been; Little Inlet has shoaled and narrowed considerably; Smith's Island (Cape Charles) has lost a great deal; the site of the old light house is about one hundred and ninety-seven feet at sea, and a break water has been built to protect the new one; the Isaacs and Fisherman Islands have made, and the Chesapeake Bay side has lost by erosion.

Accompanying Mr. Marr's report is a description with illustrative photograph of his instrument and stand, showing his method of mounting both to attain greater stability. Three stubs, about two feet long, were driven into the ground at equal distances from the center of a station and at angles of inclination in the direction of the legs of the tripod. Pointed shoes were then inserted in small holes in the tops of the stubs, and tapped until they stood firmly; then three cross-pieces were inserted in the split legs of the tripod, and a large stone or a bag of sand placed upon them. The weight of the stone or sand bag was far within the limit of strain, and a few light blows of the hand upon the stand before beginning to observe would reduce the strain to an almost constant pressure.

By this method the center of gravity of the stand and instrument is brought below the center of figure, and the stability of the stand at least is assured, especially if a platform is constructed for the observer. This can be be made of three boards supported only at the ends.

For the whole work, which was completed July 16, the following are the statistics:

Number of signals erected	28
Number of stations occupied	15
Number of objects observed upon	35
Number of points determined	24

Duty assigned to Mr. Marr later in the summer is referred to under a heading in Section I, and his assignment to the charge of one of the longitude parties on the Pacific slope in April, 1888, will have further mention under a heading in Section XI.

Hydrographic surveys and examinations in the vicinity of Cape Charles, Virginia.—Under general instructions from the Superintendent and detailed instructions from the Hydrographic Inspector, bearing date of April 25, 1888, Lieut. M. L. Wood, U. S. N., Assistant Coast and Geodetic Survey, was directed to take command of the steamer *Endeavor*, and proceed to Cape Charles, Virginia, to examine reported changes in hydrography in that vicinity.

The *Endeavor* reached Cape Charles and began work May 1. Details will be given in the next annual report. Up to the close of the fiscal year the statistics are:

Hydrography:

Area sounded, in square geographical miles	112
Number of miles (geographical) run while sounding	593
Number of angles measured	6,463
Number of soundings	24,713

SECTION IV.

NORTH CAROLINA, INCLUDING COAST, SOUNDS, SEAPORTS, AND RIVERS. (SKETCHES Nos. 1, 5, 6, 17, and 18.)

Special hydrography for the State of North Carolina completed.—The surveys and explorations of oyster beds for the State of North Carolina, made at the request of the State authorities, which have been carried on since March, 1886, by Lieut. Francis Winslow, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner *Scoresby*, were completed towards the close of the fiscal year.

All of the natural beds have been located, and the examination of the important areas has been finished. The attention called by the surveys to the value of oyster culture has led to the pre-emption of the more valuable areas, and numerous inquiries and requests for information have been received by Lieutenant Winslow. He reports that one result of his surveys has been to add forty thousand acres to the area of productive oyster fields.

Additions to the triangulation, topography, and hydrography on the coast of North Carolina between Beaufort and Cape Fear.—In accordance with instructions issued toward the close of March, 1888, Assistant W. C. Hodgkins proceeded to Beaufort, N. C., and organized a party for supplying certain needed additions to the triangulation, topography, and hydrography on the North Carolina coast between Beaufort and Cape Fear.

Work was begun April 11 at Bogue Inlet. Much difficulty was experienced in recovering the marks of the old triangulation. While this search was being prosecuted, advantage was taken of favorable opportunities for making such topographic and hydrographic surveys as were required to show the changes that had occurred. Tidal observations were also kept up at Bogue Inlet for more than a month.

After two of the old points, "Hammock" and "Humphreys," had been recovered, they were connected by quadrilaterals with a base-line which was measured on the sea-beach between Bogue and Bear Inlets, this portion of the coast being known as Bear Banks. At Humphreys station observations for azimuth were made, and the mark connected with the triangulation.

Upon the completion of work in this vicinity, Mr. Hodgkins transferred his party to New River, North Carolina, where three of the old stations were soon recovered, signals erected, and angles measured for connecting them with a check base-line laid out on the sand beach west of New River Inlet. Station Canaday on the bluff bank, west side of New River, near the old station McMillan, was occupied for observations of azimuth, and measurements made for connecting the mark with the points of the triangulation.

As opportunity offered, a topographical resurvey of the inlet was executed to show the changes that have occurred from the gradual shifting of the bar, and also the new canals that have been cut through the marshes by the U. S. Engineers.

A limited amount of hydrography was done also, to show the depth of water over the bar and up the channel to the anchorage.

In this hydrography and also in the base-measurement, Mr. Hodgkins had the co-operation of Assistant D. B. Wainwright, whose work on another portion of the North Carolina coast will be adverted to in the next heading.

The New River work was practically finished at the end of June, but the preliminary computations having shown unexpectedly large differences between the measured and computed distances, effort was at once made to discover the source of the discrepancies, and it was found that the station occupied as Swan Point was not the old point, but one about twenty feet from it, established by the North Carolina Oyster Survey. The necessary remeasurements were then made, and the survey at New River completed July 14. During the stay of the party at New River continuous tidal observations were kept up at Wright's Island, near the inlet.

Two other resurveys were made before closing field operations, one at Brown's Inlet and the other at Bear Inlet. This last named work was finished July 23, and next day the party was transferred to Beaufort on the way north.

The work having been brought to a close but a few weeks later than the end of the fiscal year, the entire abstract of its progress has been included in this year's annual report.

Other duty executed by Assistant Hodgkins is referred to under a heading in Section III.

Connection of old with new triangulation on the coast of North Carolina, and resurveys on that coast from Masonboro Inlet towards New River Inlet.—Early in April, 1888, Assistant D. B. Wainwright was instructed to proceed to the coast of North Carolina and organize a party to check the triangulation in the vicinity of Masonboro Inlet, and thence northeastward in other localities towards New River Inlet. Difficulty had been experienced the year before in recovering old stations, and this year, immediately after arriving on the ground, Mr. Wainwright visited the sites of all the old stations on the main shore, but without success until Big Pond, near what is now called Carolina Beach, was reached. Here, having found two of the former stations, he laid out a scheme of small triangulation, and made the necessary angular measurements, combining them with a base measure to join the scheme of the previous year, reference to which was made in the last annual report.

After completing this piece of work, he proceeded to check the triangulation at Sloop Point, where the two stations which were recovered were connected with a check base measured by wire upon the beach. Observations for azimuth at one of the stations were made on three nights. The shore-line in the vicinity of Barren, Queen, Rich, Ledberry, Old Topsail, New Topsail, and Stump Inlets was resurveyed, and such soundings taken as were practicable.

Towards the end of June Mr. Wainwright went to New River Inlet to co-operate with Assistant

Hodgkins in his resurveys in that locality, and upon completing that duty he discharged his party and left for Washington June 30.

The statistics of his work are:

Length of beach measurements, in miles	7
Number of stations occupied for horizontal measures	24
Number of geographical positions determined	15
Number of nights of observations for azimuth	3
Length of general coast resurveyed, in statute miles	30
Length of roads, in statute miles	4

Field duty assigned to Mr. Wainwright earlier in the fiscal year is referred to under a heading in Section III.

SECTION V.

SOUTH CAROLINA AND GEORGIA, INCLUDING COAST, SEA-WATER CHANNELS, SOUNDS, HARBORS AND RIVERS. (SKETCHES Nos. 1, 6, 17, and 18.)

Hydrographic survey of St. Simon's Bar, Georgia.—Lieut. J. E. Pillsbury, U. S. N., Assistant, commanding the steamer *Blake*, has communicated to the Office the results of his survey of St. Simon's Bar, Georgia, executed under instructions dated April 2, 1888.

He reports that the bar is changing rapidly, the North Breaker Shoal making to the southward, and the lumps at the shoaler parts increasing in height. This movement he thinks is immediately preliminary to the breaking out of a new channel at some point radically different from that now in use.

Vessels of over fourteen feet draught should wait for a rising tide to cross the bar, and those of twenty or twenty-one feet draught for high-water spring-tides.

The dredged channel to the port of Brunswick, Lieutenant Pillsbury states, is of but small value now, as it seems to be filling up. Four passages through it on the Engineer's ranges, which are now used by the pilots, gave a depth at low water of not over eleven feet. The single through cut of the dredge was originally made to fourteen feet, but it is so narrow that it is extremely difficult to find the greatest depth that now remains on it. At most of the wharves of Brunswick there is a depth equal to the draught of vessels crossing the bar.

This abstract is taken from a descriptive report submitted by Lieutenant Pillsbury to accompany his hydrographic sheet.

The statistics of the survey are:

Number of miles (geographical) run while sounding	146
Number of angles measured	2,426
Number of soundings	11,553

Other surveys executed by Lieutenant Pillsbury are referred to under headings in Sections I, II, and VI.

SECTION VI.

PENINSULA OF FLORIDA, FROM ST. MARY'S RIVER, ON THE EAST COAST, TO AND INCLUDING ANCLOTE ANCHORAGE, ON THE WEST COAST, WITH THE COAST APPROACHES, REEFS, KEYS, SEA-PORTS, AND RIVERS. (SKETCHES Nos. 1, 7, 17, and 18.)

Gulf Stream explorations, 1888.—*Observation of currents outside of the Bahama Islands; between the Great Bahama Bank and Cuba; in the Windward Channel; in the Mona, Anegada, and Windward Island Passages, and in the Equatorial Stream between Barbados and Tobago.*—For the further prosecution of his investigations of the currents of the Gulf Stream and the channels leading into it, Lieut. J. E. Pillsbury, U. S. N., Assistant Coast Survey, having re-organized his party on board the steamer *Blake*, left New York December 28, 1887, and, after coaling at Newport News, steamed to the eastward to begin his observations.

The scheme laid out in his instructions included an examination in nearly mid-Atlantic, about seven hundred miles northeast of Barbados Island, for the purpose of discovering whether an Atlantic flow exists outside of the limits of the trade-winds. After steaming nine days, the *Blake* reached her objective point in about latitude 28° north and longitude 47° west. Here she laid-to four days in a strong northwest gale and high seas, and, as the weather showed no signs of improvement, the proposed examination was reluctantly abandoned, and the steamer headed for Barbados.

Within a few days after reaching that island, observations of currents in the Equatorial Stream, between Barbados and Tobago, were begun, and seven anchorages were made in this passage. Other anchorages were made between all the islands from Trinidad to Antigua, and in the Anegada, Mona, and Windward Passages.

The results obtained at these various anchorages were of such importance, and, at times, so much at variance with preconceived ideas, that Lieutenant Pillsbury has deemed it inadvisable to complete their discussion until the results of a second year's cruise in the same localities can be made available. He will therefore postpone the preparation of a report upon the subject until he has at his command the data derived from his observations during the season of 1889.

The officers who served on the *Blake* during the season were Ensigns N. J. Halpine, R. M. Hughes, A. G. Rogers, C. S. Stanworth, and J. E. Shindal, U. S. N.; Passed Assistant Engineer G. W. Cowie, jr., U. S. N., and Assistant Surgeon T. A. Berryhill, U. S. N.

Pay Yeoman N. G. Henry and Ship's Writer W. W. Appleget rendered services as recorders, and Master-at-Arms Jens Petersen as mechanician.

Following are the statistics of the cruise of 1888: Physical hydrography:

Number of anchorages (deep-sea current stations)	34
Number of soundings (deep-sea)	56
Number of current observations with meter	2,763
Number of current observations with surface pole	1,304
Number of miles steamed	9,936

Other duty executed by Lieutenant Pillsbury is referred to under headings in Sections I and II.

Hydrographic surveys on the west coast of Florida from Pavilion Key to Cape Sable, and thence to Sandy Key and Key West.—The work executed by the hydrographic party on the steamer *Bache*, on the west coast of Florida and approaches, in the winter and spring of 1888, forms the subject of two descriptive reports submitted by Lieut. J. F. Moser, U. S. N., Assistant. These reports contain full information respecting the hydrographic characteristics of the area under survey, the available anchorages, prevailing winds, effects of tides and currents, etc., and present also suggestions in regard to surveys of the waters between the keys east of Key West, which will have much weight as coming from an officer of Lieutenant Moser's long experience in hydrographic service and thorough comprehension of its requirements.

Having refitted the steamer at Baltimore, the party left in her for Key West January 3, arrived at that port January 10, and after coaling and taking on board signal lumber and stores, was ready a day or two later to proceed to the working ground. Delay was caused by a heavy norther, but on January 16 the steamer reached Pavilion Key, and field operations were begun.

The area to be covered by the survey was included in the limits from Pavilion Key (about twenty-one miles southeast of Cape Romano) to Cape Sable, thence to Sandy Key, crossing the Bay of Florida to Lemon or East Bahia Honda Key, and from that point along the line of Bay Keys to Northwest Channel at Key West, and seaward to the ten-fathom curve.

Over this area the work was prosecuted vigorously until its completion, May 10, thus finishing the last gap remaining in the coast hydrography from Eastport, Maine, to the Delta of the Mississippi. For the first four weeks the weather was favorable, and progress rapid, but during the rest of the season there were frequent northers, and the intervals between these were filled in by strong easterly winds, amounting at times to heavy gales.

The triangulation along the coast as far as Cape Sable having been finished during the year preceding, and most of the signals still standing, this was of much advantage in the prosecution of the hydrography, but in making the connection between Cape Sable and the easternmost key of the group to the eastward of Key West, it became necessary to re-establish points on that group from such marks of the triangulation of 1856–1858 as could be recovered. A few of these were found after diligent search; their positions carefully re-marked and descriptions furnished for office use.

Between Pavilion Key and Cape Sable there are several shallow tortuous channels from four to six feet in depth, leading between the keys towards the main-land; to these Lieutenant Moser calls attention as perhaps deserving of development after the topography has been done. The most important of these are the entrances to Lostman's River, Rodgers River, and Shark River.

The slope of the bottom is very regular between Pavilion Key and Cape Sable, or, as it is more generally known in the locality, East Cape. The depths increase gradually to the ten-fathom curve. Off East Cape the bottom becomes irregular, and this irregularity increases in a line towards East Bahia Honda Key or Lemon Key. From thence to Content Key, and seaward to the three-fathom curve it is very much broken. Shoals awash, or nearly so, at low water are numerous, and extensive banks dry at low water may be found five and six miles from shore. Narrow, tortuous channels intervene, ending in *cul-de-sacs*, or spread out over great areas of very shallow water. There are also many holes with three or four fathoms of water.

The survey of these waters was difficult and laborious, as no land could be seen from the outer shoals. Lieutenant Moser succeeded, however, in locating signals on the shoals, and, from these and a few water signals, in fixing his lines of soundings.

From Content Key to the Northwest Passage at Key West the bottom again assumes a regular form, the three-fathom curve approaching the shore line within a mile. Several shallow channels pass through the line of reefs connecting the Bay Keys. With regard to these Lieutenant Moser observes that if it is desirable that these channels should be surveyed, it can only be done advantageously from an inside position, and in a vessel adapted for the purpose. Whatever channels exist, run across the line of keys in a north and south direction, and do not communicate in an east and west direction. There are two main channels running from the reefs to the Gulf, which are used by small vessels, and which should be thoroughly surveyed. One called the Spanish Key Channel, which runs from Bahia Honda, west of Big Spanish Key and east of Harbor Island into the bay, the entrance of which, as far as Big Spanish Key, was traversed by the party; the other Knight Key Channel, which runs west of Knight Key, and thence between banks, entering the bay east of Bahia Honda Key.

From the reefs to Mayo's Key the Spanish Key Channel is broad, deep, and wide, but from thence to the Gulf it varies in depth and becomes narrow and tortuous. About six feet can be carried through this channel. The work did not touch upon the Knight Key Channel; it was reported, however, that seven feet could be carried through it. From Pavilion Key to East Cape the keys have a thick growth and are so blended that the appearance is that of a continuous shore-line, the entrances being apparent only on a very close approach. There are no marked prominent features such as would enable a stranger to distinguish one portion of the coast from another. Pavilion Key is more prominent on approaching from a westerly point, and has a sand beach on the western side. On Lostman's Key there is a beach along the entire Gulf face. A beautiful beach extends from North Cape to East Cape. There are several small buildings at Middle Cape, with the roofs painted red and a prominent palm tree back of the houses. At East Cape there are two small buildings with red roofs. Between Middle Cape and East Cape is a dwelling, and back of it a grove of palms, which is conspicuous and a good land-mark.

The Bay Keys from Northwest Channel to the eastward are quite similar in appearance, differing chiefly in size, but as these keys, as far as Content Key, can be approached very closely with deep water, and as they are not so thickly clustered, their shapes are more readily made out. The timber has been thinned out for use at Key West. Sawyer Key has a sand beach along the Gulf face.

The best guide on approaching the coast is the lead, and it is a safe guide, except on the broken ground before referred to.

A safe anchorage is afforded by the shallow water of the coast in any weather except a hurricane. During the cruise of the *Bache* the prevailing winds were easterly and the heaviest gales were northers and southeasters.

With regard to the tides, Lieutenant Moser observes that they form a very important factor in the hydrography of that coast, and he urges the importance of establishing a permanent tidal station at some well selected point on the west coast of Florida.

Special attention was given to careful determinations of tidal action within the area of the survey. At some point of the work, from the day of opening until the close of the season, a continuous series of day and night tides was observed. Three principal tidal stations were established, one on Lostman's Key, one on Cape Sable (East Cape), and one on Content Key; at each of these, observations were kept up during forty-six, forty-four, and twenty-nine days, respectively. Five comparison gauges were established also, two of these being off-shore in five and seven fathoms water.

At these off-shore stations a Batchelder pressure-gauge was used, which worked perfectly. Observations for currents were made also.

Since the data obtained by the tidal reductions relate to a hydrographic survey covering an area in which the extremes differed as much as four hours in time and several feet in rise and fall, this area was laid out in blocks in order to make the reductions apply as accurately as possible, each block having special reference to a central station. These blocks were graded one into the other, so that at no points were the differences greater than one-half hour in time, or four-tenths of a foot in rise and fall.

Lieutenant Moser has appended to his report full notes descriptive of each block, with the methods of reduction employed; the limits of the blocks he has indicated on the sounding sheets.

The abstract here given recites merely the salient points of the report with reference chiefly to their bearing upon the immediate objects of the hydrographic survey; other topics of interest discussed in it, relative to the geological formation of the coast, the fisheries, etc., must, for want of space, be omitted.

The results of the season's work are shown upon four hydrographic sheets, as follows:

No. 1. Florida Bay, Pavilion Key to Northwest Passage Light-House; scale, 1–80000.
No. 2. Florida Bay, Pavilion Key to Northwest Cape; scale, 1–40000.
No. 3. Florida Bay, Northwest Cape to Content Key; scale, 1–40000.
No. 4. Florida Bay, Content Key to Northwest Passage Light-House; scale, 1–40000.

The statistics are:

Number of miles (geographical) run while sounding	3,791
Number of angles measured	10,520
Number of soundings	90,811
Number of specimens of bottom preserved	28
Number of current stations	2

The officers attached to the party during the season were Ensigns Franklin Swift, W. O. Hulme, H. A. Bispham, and G. R. Evans, U. S. N.; Passed Assistant Surgeon J. M. Steele, U. S. N.; and Assistant Engineer S. H. Leonard, U. S. N. Mr. J. L. Dunn served as Pay Yeoman.

Lieutenant Moser expresses his especial appreciation of the services rendered by Ensign Swift as executive officer; Ensign Hulme, who had charge of all the draughting, and Ensign Bispham, to whom was committed the immediate charge of all details relating to the tides.

He commends also all the other officers for their interest in the work, and the thorough manner in which it was executed.

Duty assigned to Lieutenant Moser earlier in the fiscal year is referred to under a heading in Section I.

Topographical survey of the west coast of Florida between Pavilion Key and Cape Romano.—The prevalence of yellow fever at Tampa and Manatee, on the west coast of Florida, in the autumn and early part of the winter of 1887, delayed the resumption of the topographical survey of that coast till January, 1888. Under instructions dated towards the end of December, 1887, Assistant Joseph Hergesheimer arrived at Manatee, Fla., and organized his party on board the schooner *Quick*. Messrs. J. H. Gray, Aid, R. J. Meigs, Recorder, and Atlee Johnson, Foreman, reported for duty at Fogartyville, Manatee River, on January 18.

Having fitted the schooner for sea, the *Quick* reached the working ground February 2, and was anchored off Indian Key. Plane-table work was begun February 4. The survey covered the coast from Pavilion Key to Cape Romano, a distance of thirty-one statute miles, and included within its limits the outside line of keys, with the adjacent bays and harbors for a belt of from one to two miles in width. The line of reef or rocks on the outside islands was all surveyed at low water.

Mr. Hergesheimer reports that he found Mr. Gray to be a careful, correct, and rapid topographer. Field observations were closed April 17. Following are the statistics:

Number of miles of shore-line surveyed	167
Number of miles of coast-line surveyed	31
Area surveyed, in square miles	34

After disbanding his party and laying up the schooner at Fogartyville, Mr. Hergesheimer returned north in May, and was directed to hold himself in readiness to resume work on the connection of the Pennsylvania and Maryland triangulations, progress in which he had made earlier in the fiscal year, as reported under a heading in Section II.

SECTION VIII.

ALABAMA, MISSISSIPPI, LOUISIANA, AND ARKANSAS, INCLUDING GULF COAST, PORTS AND RIVERS.
(SKETCHES Nos. 1, 6, 8, 17, and 18.)

Continuation of the reconnaissance and triangulation for connecting the primary triangulation near Atlanta with that of the Gulf.—For the continuation of the reconnaissance and triangulation for extending an oblique arc of the meridian towards the Gulf of Mexico by connecting the work near Atlanta, Georgia, with that on the Gulf, Assistant F. W. Perkins took the field about the 1st of February, 1888. Although his instructions had been issued the middle of December, it was deemed inadvisable to begin operations until most of the unfavorable weather so prevalent in that section during the winter had ceased. The reconnaissance was taken up in Alabama in latitude 33° 20′, and carried south by means of two figures of good condition to latitude 32° 16′. Mr. Perkins observes that the most laborious part of the work in the northern figure had been done by Assistant Tittmann, who had had charge of the work during the preceding season. Lowndesborough, in Lowndes County, Alabama, was the most southern point selected. From thence southward, although the country is very flat, figures of good size can probably be obtained by careful studies of its peculiarities.

Towards the end of March, heavy floods put a period to the reconnaissance, and retarded much the work of preparing for occupation the stations that had been selected. The condition of the roads and streams made such long detours necessary that observations were not begun until the last week in April, a month having been consumed in work that, under more favorable circumstances, could have been done in a fortnight. Stations Laurel and Horn were completed, and about one-half of the observations necessary at Weogufka had been made, when, on the 1st of June, it became necessary to disband the party owing to the exhaustion of the funds available for this survey.

Mr. Perkins expresses his obligations to Mr. W. B. Fairfield, extra observer, whose skill in reconnaissance made his services of exceptional value.

The statistics reported are as follows:

Reconnaissance:	
Area of, in square statute miles	3,250
Triangulation:	
Area of, in square statute miles	1,050
Aggregate length of lines of (primary)	400
Aggregate length of lines of (secondary)	180
Number of days occupied in opening and verifying lines of sight	15
Number of stations occupied	3
Number of points observed upon	17
Number of angles measured	27
Number of geographical positions determined	1

Under a heading in Section XIV, reference is made to duty executed by Mr. Perkins earlier in the fiscal year.

Survey of the Mobile River from Spanish River to the junction of Alabama and Tombigbee Rivers.—In order to obtain data for a useful chart of Mobile River, Mr. J. H. Turner, Aid, was instructed in January, 1888, to make a rapid survey of that river from the limits of the topographical sheets at Spanish River, near Mobile, up to and including the junction of the Alabama and Tombigbee rivers. The topography along the river banks only was to be delineated, all the bluffs and their heights being shown, and special attention was to be given to the hydrography.

Mr. Turner has submitted full reports of his survey, arranged as special and descriptive reports relating to the triangulation, topography, and hydrography. The work was completed between January 23 and April 30. Acknowledgment is made to Maj. A. N. Damrell, U. S. Engineers, for his kindness in loaning a steamer specially adapted for the survey. Also to the people of Mobile for the interest they manifested.

It had been originally intended to make the preliminary triangulation with the plane-table, but this plan proved upon examination not to be practicable, as the country bordering upon the river is, with few exceptions, a heavily wooded swamp, the trees overhanging the banks. Recourse was accordingly had to a small triangulation, extending in a chain of quadrilaterals from the Spanish River to the limits of the survey, the distances apart of the signals varying with the width of the river, from forty to four or five hundred meters, the angles being measured by sextants; short bases measured at intervals frequent enough to supply suitable checks, and azimuths carried up the river by axial lines. All of the azimuth angles were measured with a six-inch theodolite, and three stations were occupied for observations for azimuth on the sun, one at Spanish River, one at Twenty-one Mile Bluff, and one at Mount Vernon Landing. These observations were made with a three-inch alt-azimuth. The length of river covered by the triangulation was forty miles.

As heavy and expensive cutting would have been required in using the plane-table, it was employed only where the high pine lands touched the river, forming bluffs; these were carefully mapped. In other parts of the river the shore-line being very regular, it was sketched in between the stations, and all irregularities were noted. The various bayous were explored for short distances.

The hydrography was executed by running lines of soundings at right angles to the axis on ranges from signal to signal, and at distances apart of one hundred meters, connecting these lines by diagonals. This plan was carried out till towards the end of the season, when a limitation as to time compelled the substitution of stream lines, with normals at greater intervals. The soundings showed that, contrary to general report, the river was singularly free from shoals, the channel being comparatively broad and sharply defined throughout its entire length. Between Spanish River and the junction of the Alabama and Tombigbee, but two *bulwarks* occur, and on these the depth is seventeen feet. The shoals which occur in the angles of the bends do not extend far enough from shore to be dangerous to navigation.

Mr. E. M. Talcott served as Recorder in the party. Mr. Turner acknowledged his indebtedness to him for faithful and energetic service, and for many valuable suggestions which contributed to the accuracy of the work.

The statistics are:

Triangulation:	
Area of, in square statute miles	8
Number of signal poles erected	596
Number of days occupied in opening and verifying lines of sight	15
Number of stations occupied for horizontal measures	575
Number of geographical positions determined	600
Number of azimuth stations	3
Topography:	
Area surveyed, in square statute miles	15
Length of shore-line of rivers, in statute miles	85
Length of shore-line of creeks, in statute miles	4
Length of shore-line of ponds, in statute miles	3
Length of roads, in statute miles	5

Hydrography:

Area sounded, in square geographical miles	8
Number of miles (geographical) run while sounding	135
Number of angles measured	2,860
Number of soundings	11,300
Number of hydrographic sheets finished (scale, 1–5000)	9

The hydrography was plotted upon the topographic sheets; there are therefore nine sheets in all.

During the first five months of the fiscal year Mr. Turner was on duty in the party of Assistant Eimbeck, in Utah. Reference to his work there is made under a heading in Section XVI.

Lines of geodetic leveling run between the Mississippi River and Little Rock, Arkansas.—The organization of a party for connecting by lines of spirit leveling of precision the city of Little Rock, Ark., with a bench-mark of the Mississippi River system of geodetic leveling, was intrusted to Subassistant J. E. McGrath by instructions issued towards the end of September, 1887. Upon reaching Little Rock, he was directed to communicate with Prof. J. C. Branner, Director of the Geological Survey of Arkansas, and consult with him with reference to the route to be followed, and, before taking up the work, to make a thorough reconnaissance of the several routes by which the river might be reached from Little Rock.

Mr. McGrath arrived in Little Rock on October 16, and, after seeing Professor Branner, made an examination of three routes, each of which would enable him to connect lines of geodetic leveling from that city with a primary bench-mark of the Mississippi River Commission. The route finally adopted was that of the Little Rock, Mississippi River and Texas Railroad from Little Rock to Arkansas City, on the Mississippi River. This road runs through a high and rocky stretch of country from Little Rock to Pine Bluff, a distance of about forty-three miles; it then descends into the low lands, but in a belt which is entirely above overflow until Trippe Junction, a station seven miles west of Arkansas City, is reached. From Trippe the road runs down to the river on a well built, substantial embankment, one which has not been overflowed for three years.

The high grade of this line, its shortness (one hundred and fourteen miles), as compared with the other two lines, its small amount of trestle-work, and the convenience it offered to the party in getting to and from their work, made it the most favorable route, and its termination at a point near Wilkerson's Landing, on the Mississippi River, was also an advantage, as this point was much nearer Greenville, the end of the Coast and Geodetic Survey line of precise leveling on the Mississippi, than points at either Helena (Arkansas) or Memphis would have been.

Owing to the possible prevalence of wet and stormy weather late in the season, it was decided to work westward after a crossing of the river had been effected. The first work done was in compliance with Professor Branner's request to make a crossing of the Arkansas River at Little Rock, and connect the east monument of the U. S. Engineers' base near the river bank with the primary bench-marks in the city.

The party was then transferred to the east end of the line, and, having started at the permanent bench-mark of the Mississippi River Commission at Wilkerson's Landing, Bolivar County, Miss., connections were made with the secondary bench-marks of the Commission, and the river was crossed into Arkansas, two methods being used, one that of simultaneous and reciprocal observations, carried on by Mr. McGrath and by Mr. John Nelson, Aid in his party, and the other by means of water-gauges, which were carefully observed and then connected with the bench-marks of the line of precise leveling. The work was then carried westward.

At various times during the season, in accordance with instructions, Dr. Branner was furnished with the heights and descriptions of such bench-marks as would be of use to him in connection with the topographical and geological survey of the State under his direction, and at the close of the season complete lists of bench-marks established by the party, with their heights and descriptions, were communicated to him.

On February 11, the work having been completed, field operations were closed.

The method pursued throughout was that of running two single lines of precise leveling in opposite directions by different observers, Mr. McGrath taking the line in one direction and Mr. Nelson in the other.

Of Mr. Nelson's services Mr. McGrath speaks in terms of high praise, both as regards the accuracy and the rapidity of his work. Mr. F. A. Young, Recorder, was zealous and faithful.

The observations have been discussed in the Office, and their results presented in Appendix No. 12, to this volume.

Other duty assigned to Mr. McGrath is referred to under headings in Sections II and XV.

Triangulation, topography, and hydrography of the Atchafalaya River, and detached surveys on the coast of Louisiana.—In December, 1887, Assistant C. H. Sinclair, having received instructions to make certain surveys needed on the coast of Louisiana west of the Passes of the Mississippi, proceeded to New Orleans, and having had the steamer Hitchcock repaired and made ready for sea, left in her for Morgan City by way of the Mississippi River and the Gulf.

An azimuth being required on Last Island, to give direction to the triangulation in that locality, Mr. Sinclair stopped there and occupied Raccoon station on the west end of the island, placing an azimuth mark about a mile to the eastward, and referring it to Ship Shoal Light-House. He was detained here a week by cloudy weather. Leaving Last Island January 28, 1888, the steamer arrived at Morgan City on the 30th, having stopped at Shell Island on the way to establish there, by the kind permission of the owner, a depot for supplies of coal, lumber, etc.

It had been intended at the outset to execute a survey of verification at Southwest Pass, Vermilion Bay, but as from circumstances over which they had no control, the officers assigned to Mr. Sinclair's party were unable to join him till much later in the season, he took up at once the reconnaissance and triangulation of the Atchafalaya River and its connection with the triangulation on the Gulf coast.

As a base of operations the line Deer Island-Belle Isle was used; the reconnaissance and erection of signals was pushed rapidly, and the principal part of the triangulation was completed by the middle of March. On account of the tall marsh canes fringing the river, it was necessary to put up observing tripods for even short lines. When the last quadrilateral was reached, it became necessary to open lines across marsh that could not be passed over in a direct line, as it was covered not only with tall cane, but crossed by ridges of willows from thirty to fifty feet high that could only be reached by entering at certain places and getting on line by trial, the marsh being too soft to allow a line to be followed up from one end to the other on range.

North of the most advanced signals the cypress woods are very lofty, and it was not deemed advisable to push the triangulation through them by cutting. Points enough had been determined by March 9 to start the topography, and work on the lower sheet was taken up by Mr. J. A. Flemer, Aid in the party. Subassistant E. L. Taney arrived March 24, and having organized a separate party, executed the topography on the upper sheet as far as Morgan City.

Meantime Mr. Sinclair went to the coast stations to measure the angles at Belle Isle, Point au Fer, and Deer Island; to examine the ground for a check base, and to have observations made for latitude and azimuth. Latitude was determined at Station Deer Island by Subassistant P. A. Welker on five nights with meridian telescope No. 6, and an azimuth measured by Mr. Sinclair, using theodolite No. 82.

Upon the completion of the topography of the lower river, the hydrography was begun April 3. Mr. Flemer assisted with the hydrography till April 15, when he was recalled to Washington for other duty. On that date Mr. Taney disbanded his own party and joined the steamer, and after finishing the topography to Morgan City, aided in the hydrography till its completion. During the hydrographic work, tidal observations were made at Shell Island, and the tide-guage established there was referred to suitable marks.

Field operations were closed April 27, and the steamer was laid up at Bayou Bœuf alongside the property of the Morgan Steam-ship Company, Mr. Natali, agent of the line, having kindly granted permission to this effect.

The statistics of the season are:

Triangulation:	
Number of stations occupied for horizontal measures	11
Number of geographical positions determined	83
Latitude and azimuth work:	
Number of latitude stations occupied	1
Number of azimuth stations occupied	2

Hydrography:

Number of miles run while sounding	243
Number of soundings	17,193

Other services performed by Mr. Sinclair are referred to under headings in sections X, XI, and XVI, and also under "Special operations."

Topographic surveys on the coast of Louisiana between Vermilion Bay and Calcasieu Pass.—Topographic survey of the Atchafalaya River, Louisiana.—A topographical survey of the chain of islands known as the Cheniers, between Vermilion Bay and Calcasieu Pass, coast of Louisiana, was executed by Subassistant E. L. Taney in the winter of 1887-'88 under instructions dated December 22, 1887.

From Cameron, Louisiana, where the work was begun, it extended a distance of forty miles to the end of a ridge on the coast beyond the crossing of the Mermentau River. This ridge finally develops into a great number of small islands in the marsh, separated by deep "coups." This string of islands and coups was surveyed by chain and compass.

Returning to Grand Chenier, Mr. Taney hired a sloop and proceeded to complete the survey of Mermentau River from his point of crossing towards its mouth, to join Assistant Hodgkins' work of 1884. Hog Bayou and Bayou La Bovi were also surveyed, the work being done by the aid of an azimuth compass, and the points checked as often as possible by bearings taken to stations of the triangulation.

After the completion of the topographical survey of this part of the coast, March 18, Mr. Taney joined the steamer *Hitchcock*, reporting to Assistant Sinclair for duty March 22. He was then detailed with a separate party to make a plane-table survey of the Atchafalaya River, and completed the upper sheet of this work, to the railroad bridge at Morgan City, April 15, the lower sheet having been finished by Mr. Flemer. He then aided in the hydrographic survey of the river until April 27, when field operations were closed for the season.

The statistics reported are:

Topography for the Chenier Islands:	
Area surveyed, in square statute miles	117
Length of general coast-line (fast land) in statute miles	122
Length of shore-line of rivers in statute miles	16
Length of shore-line of ponds in statute miles	30
Length of shore-line of bayous in statute miles	25
Topography for the Atchafalaya River:	
Area surveyed, in square statute miles	24
Length of shore-line of river in statute miles	24

Reference is made under a heading in Section I to oth er duty assigned to Mr. Taney.

Hydrographic surveys on the coast of Louisiana between Isle Dernière and Big Constance Bayou, including Vermilion Bay.—The hydrographic surveys executed by Lieut. F. H. Crosby, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer *Gedney*, between February 1 and May 24, 1888, included the hydrography of Vermilion Bay, Louisiana, and the continuation of the off-shore hydrography of Louisiana to the ten-fathom curve from Isle Dernière to longitude 91° 40′ west.

For the survey of Vermilion Bay, the scheme laid out comprised four hydrographic sheets, each on a scale of 1-20000, and for the outside work two hydrographic sheets, each on a scale of 1-80000.

With these sheets, which have been completed and sent to the Office, Lieutenant Crosby has submitted descriptive reports. The coast in the localities of his survey is very low, with occasionally a clump of live oak trees, and at rare intervals a building.

At Chinière le Ligne there is a small fishing settlement. During summer the prevailing winds are southeast, the heaviest gales coming from that direction, except the hurricanes, which come from the southwest, and only in September and October. In winter the heaviest gales or "northers" come from the northwest. Wrecks are almost unknown. The currents set to the westward as a rule, but they are very sensitive to the action of the wind. With the exception of Trinity Shoal, which is gray sand, and the numerous shell reefs nearer shore, the bottom is very soft mud.

In the channel through Southwest Pass into Vermilion Bay, Lieutenant Crosby states that the greatest depth of water is about one hundred and fifty feet, and the least seven and a half feet on the outside bar. The channels are practically permanent. The bay is used chiefly in the transportation of lumber and cattle; the former by light-draught schooners and the latter by steamers. There are extensive salt mines on Avery's Island, about six miles up Petit Anse Bayou, from the bay, but the salt is shipped by rail to New Iberia.

At the eastern point of the entrance to the Pass are the ruins of an old light-house lying in the water and showing white at a distance of three or four miles. Lieutenant Crosby observes that a light-house or a tower at this point would greatly aid strangers in finding the entrance to the Pass.

The officers attached to the party were Ensigns R. O. Bitler, Joseph Strauss, and D. S. Nes, U. S. N.

For the season the statistics are:

Area sounded, in square geographical miles	959
Number of miles (geographical) run while sounding	2,513
Number of angles measured	9,353
Number of soundings	108,266
Number of tidal stations established	6
Number of specimens of bottom preserved	59

Report is made of hydrographic surveys executed during the fiscal year by Lieutenant Crosby upon the coast of Maine under a heading in Section I.

SECTION X.

CALIFORNIA, INCLUDING THE COAST, BAYS, HARBORS, AND RIVERS. (SKETCHES Nos. 2, 9, 10, 16, 17, and 18.)

Resurveys and examinations in San Diego Bay and vicinity.—Tertiary triangulation and topography between San Diego and San Pedro Bays.—Reference was made in the last annual report to the progress of the trigonometrical determinations, shore-line surveys, and examination of changes in San Diego Bay and vicinity by Assistant Aug. F. Rodgers, aided by Subassistant Isaac Winston. This work was completed at the end of July, 1887; its results were shown by tracings of three topographic sheets, containing nearly fifty miles of shore-line, and by an abstract of eighty new geographic positions. Towards the end of August the tracings and computations having been finished, they were forwarded to Washington.

Mr. Rodgers refers in his report to some statistics which show the extremely rapid development within a few years past of the city of San Diego, one item of which may be here mentioned—the custom-house receipts, which in 1885 were $8,000, and in 1887, $257,000.

Between the end of August and the close of field operations in December, Messrs. Rodgers and Winston were occupied in a reconnaissance for stations of a tertiary triangulation to connect the San Diego Bay surveys with those brought southward from San Pedro; with the observations of horizontal angles until a junction of the two surveys had been effected, and with a topographic survey laid out upon five plane-table sheets, scale 1–10000, including the shore-line and all of the salient topographic features in sight from the coast, among these being the town sites and all buildings in Oceanside, Carlsbad, Leucadia, Encinitas, Del Mar, and La Jolla. Great care was taken to leave nothing undetermined within the limits of these sheets which could be of importance to the mariner or available for future hydrographic work. The plane-table work was greatly strengthened and facilitated in execution by the numerous secondary objects which had been fixed in position; these consisted of some thirty-eight buildings, church-spires, school-houses, hotels, and other notable structures.

In the course of a comparison which he made of part of the shore-line of False Bay, including the sand-spit which forms its western boundary, Mr. Rodgers found no evidence of marked change since the date of the first survey nearly forty years before. In addition to the five topographical sheets already alluded to, a sixth, or supplementary sheet, was projected to complete the delineation of the connections of railroad and wagon-roads extending north from San Diego Bay and round the limits of False Bay; on this sheet was laid down also the position of the new wharf built at Roseville upon the shore of San Diego Bay.

Upon the close of field operations, December 17, Mr. Rodgers disbanded his party and proceeded to San Francisco. From the date of his arrival, December 25, he was continuously occupied until towards the middle of April in revising field computations, inking and tracing plane-table sheets, and in preparing the results of his work for transmission to the Office.

Two of the original sheets of San Diego Bay were inked and traced, the tracings being filed in the Sub-office, and the originals forwarded to Washington. A tracing of the third San Diego sheet was forwarded, and the original retained for possible future use in determining changed locations of bar and whistling-buoys at the entrance to the bay. Tracings of the five original sheets of survey of the coast-line for a distance of forty-five miles north of San Diego Bay were made and forwarded, together with a tracing of the supplementary sheet, and all the records and results of the triangulation.

On February 23 Subassistant Winston was detached and ordered to other duty. His services Mr. Rodgers refers to as having contributed greatly to the success of the season's work.

In April, instructions having been received to resume field operations in southern California, Mr. Rodgers left San Francisco on the 27th of that month, and early in May began the erection of signals for the interior topography north and south from Oceanside, San Diego County. On June 12 the progress of this topography was temporarily suspended by instructions directing him to go to San Juan Capistrano, and lay down upon the topographic sheet of that locality the new line of the California Central Railroad. This was accomplished by the 20th instant, when the Oceanside work was resumed.

Subassistant John E. McGrath reported for duty June 21. At the close of the fiscal year twenty square miles of interior topography north and south of Oceanside had been completed, and the work was in active progress.

Following are the statistics reported for the fiscal year:

Reconnaissance:	
Area of, in square statute miles	50
Lines of intervisibility determined as per sketch submitted	393
Number of points selected for scheme	68
Triangulation:	
Area of, in square statute miles	100
Number of signal poles erected	68
Number of stations occupied for horizontal measures	68
Number of stations occupied for vertical measures	35
Number of geographical positions determined	191
Number of elevations determined trigonometrically	76
Topography:	
Area surveyed, in square statute miles	100
Length of general coast line, in statute miles (San Diego Bay and coast)	92
Length of shore-line of creeks, in statute miles	15
Length of roads (including railroads), in statute miles	120
Number of topographic sheets showing coast-line and elevation	9
Scale of topographic sheets	1–10000

With regard to the tertiary triangulation and the shores of San Diego Bay and northward therefrom, Mr. Rodgers observes that it was checked at every stage of progress by providing double determinations of every advanced base by means of diagonals, and that it was finally checked in length and azimuth by establishing the first junction between two carefully measured bases, one hundred miles apart, one on the shores of San Diego Bay, the other a few miles inland from the roadstead of San Pedro.

Special hydrographic examinations at San Juan Capistrano, La Ballona, and at Newport and San Pedro Bays, California.—In accordance with instructions, and under the direction of Assistant George Davidson, Mr. Ferdinand Westdahl made a minute examination of the approaches and anchorage of San Juan Capistrano for the map already made. This was done in much detail, and the soundings were reduced for the tide by comparisons with a tide-staff set up at Newport Landing, where regular observations were continued. The weather at San Juan was adverse; fogs and strong winds prevailed, and the landing through the surf was dangerous. The boat was capsized twice. This work was all reduced, plotted, tracings made, and the sheets and records transmitted to the Office.

At La Ballona the projected piers were determined in position by connecting them with the regular triangulation and topography. As the proposed dredging had not been executed, there was no need of a detailed examination.

At San Pedro Bay, the Crapo sunken rock, having seventeen feet of water upon it, was carefully examined and two heads were discovered. Further examination was made to determine whether there was any line of submerged rocks hence to Deadman's Island, and also further out in the anchorage. No other danger was detected.

Mr. Davidson had reported that four different vessels had been upon this rock before it was buoyed. The rock was connected by observation with the regular work of the Survey and the location of the buoys fixed. The city plans of Long Beach and Alamitos were reduced.

At Newport Bay, under Mr. Davidson's direction, Mr. Westdahl made a special examination of the physical hydrography off the beach to the west of Newport Bay entrance, where one of the great submarine valleys heads. This work was at once reduced, and the records and sheets sent to the Office.

Other hydrographic work executed by Mr. Westdahl, under the direction of Mr. Davidson, is referred to in a later heading of this section.

Examination of the site selected for the measurement of a primary base-line near Los Angeles, California.—An account was given in the Annual Report for 1886 of an examination made in May of that year to obtain a site for a base-line to be used instead of the San Pedro base, one of the terminal markings of which had disappeared.

A site was selected, but no funds for the measurement being immediately available, it was postponed. In June, 1888, it became probable that the measurement might soon be made; instructions were given, therefore, for a re-examination of the site with reference to its freedom from impediments. This examination was made on June 9 by Subassistant Fremont Morse, under the direction of Assistant George Davidson.

Mr. Morse drove over the line from its northeastern to its southwestern end. Near Northwest Base he found the base site crossed by the new line of the Atchison, Topeka and Santa Fé Railroad, which runs nearly parallel with that of the Southern Pacific, and crosses the base-line at about the same angle, about half way between Northwest Base and the Southern Pacific crossing. But as there is no *fill* at the point of crossing there is no obstruction to measurement of the base. Neither do the few wire fences that have been put up south of the Southern Pacific crossing and between it and the first ranch house offer any obstruction.

An early measurement is, however, as Mr. Morse reports, exceedingly desirable on account of the great rapidity with which the country in the vicinity is being settled. An instance of this is the growth of the town of Whittier, three or four miles north of Anaheim. When the base was located in 1886 no such town was in existence; it has now some 2,500 inhabitants. Another thriving town, still nearer the line of the base than Whittier, is Fullerton, built up entirely since 1886.

Towards Southeast Base the soil, which for some distance from Northwest Base is alkaline, grows better and more adapted for agricultural purposes. The land which is not inclosed and cultivated bears a heavy crop of natural grasses and wild mustard. The mustard stalks are from eight to ten feet high, giving ample evidence of the fertility of the soil.

Magnetic record continued at the self-registering magnetic station at Los Angeles, California.—Absolute measures of the magnetic elements made monthly.—Assistant R. E. Halter has submitted a report of his work at the magnetic observatory, Los Angeles, California, for the fiscal year. At this station a continuous record of the variations of the magnetic elements is kept up by means of the Adie magnetographs, and absolute measures are made on three days of each month.

Near the beginning of the year some changes were found necessary in handling the sensitive paper and in other parts of the routine work; these were made with satisfactory results. A new azimuth mark had to be established, a house having been erected in line between the observatory and the mark first employed. In January, 1888, the lower observatory used for absolute measures was nearly washed away by heavy rains; this made it necessary to raise the building and the pier, which was done in time for the February determinations.

The usual semi-annual observations for scale values were made on December 29 and June 26.

On January 6 Mr. Halter found it necessary to re-balance the vertical-force magnet, the magnet spot being nearly off the cylinder. The scale value was again determined immediately afterwards.

During the month of October the clock was stopped by a mole or gopher, and seven hours' record was lost, and on the 17th of May the vertical force lamp was extinguished by a bird or a bat, and one hour's record was lost. On June 12 the winding cord caught in the pendulum of the clock, and seven hours' record was lost. Hence the total loss of record during the year was fourteen hours of the unifilar, fourteen hours of the bifilar, and fifteen hours of the vertical force. The development of the traces throughout the year was remarkably good.

Absolute measures of the magnetic declination, dip, and intensity were made regularly on the 14th, 15th, and 16th of each month without interruption. Observations for time were made on the 1st of each month, or as soon after as possible. The records, computations, and duplicates were kept up to date, and forwarded every month to the Office.

In the routine work and with the records Mr. Halter was assisted by Mr. W. P. Miles.

For the fiscal year the statistics are:

Number of observations for time	384
Number of observations for temperature	4,750
Number of unifilar hourly scale readings	8,746
Number of bifilar hourly scale readings	8,746
Number of vertical force hourly scale readings	8,745
Number of observations for absolute declination	1,440
Number of observations for absolute intensity	1,584
Number of observations for absolute dip	3,580
Number of observations for azimuth	32
Number of observations for scale values of bifilar and vertical force magnets	882

Tertiary triangulation and topography on the south coast of California.—An abstract was given in the last annual report of the work of the party in charge of Assistant Stehman Forney on the south coast of California in advancing the topographical survey on that coast towards San Simeon Bay.

A junction having been effected with Assistant Rockwell's survey at San Simeon about the beginning of the fiscal year, Mr. Forney moved his party and camp to San Carpoforo Creek, the western terminus of Mr. Rockwell's work, and took up a tertiary triangulation which he carried westward to Cape San Martin, connecting it also with the primary triangulation stations Rocky Butte, Cone Peak, and Santa Lucia. At the two stations last named he erected large signals.

By December 22 he had completed the topography of the coast to the limits of the first plane-table sheet as far west as Buckeye Cañon. Field operations were then suspended for the season.

The statistics are:

For the triangulation:	
Number of stations occupied	15
Number of signals erected	17
Number of points observed upon	22
For the topography:	
Number of miles of shore-line surveyed	7
Number of miles of roads surveyed	29
Number of miles of creeks surveyed	32
Number of miles of fencing	51
Number of miles of trails	12
Area (approximate) surveyed in square miles	29

During the remainder of the winter and until the end of April, 1888, Mr. Forney was engaged in completing his records and in tracing and inking his topographical sheets. Having received instructions to resume field-work, he left San Francisco May 1 and proceeded to Cambria, San Luis Obispo County, where he organized his party and took up the extension of the coast triangulation northwestward from the line China Gulch-Yellow Hill to the line San Martin Top-Alder Top, and the topography from the mouth of the San Carpoforo Creek northwestward to Villa Cañon. The work involved the erection of large signals at twelve stations of the triangulation close to the coast, and at two stations, Rocky Butte and Santa Lucia, of the main triangulation. In putting up these signals much time and hard labor was spent, the country being rough and transportation difficult. In compliance with instructions the contour curves for the topography were carried to the summits of the coast range, which varied in distance from the ocean between one and a half and four miles.

On June 17 and 20 Mr. Forney determined the positions of two sunken rocks in Twin Peak Bay.

The topographical sheet upon which he was occupied at the close of the fiscal year included the rich gold mines discovered a year ago, yielding three tons of ore per day, each ton producing gold to the value of $600. Other mines have been opened in the vicinity, but have not as yet proved productive. This mining region is on Alder and Willow creeks, and extends from the ocean to the summit of the coast range.

In Villa Cañon there is a fine grove of silver fir trees, covering about fifty acres of ground, and containing about two thousand trees. Some of these are two hundred feet in height and four feet in diameter at the base.

Further report of the progress of Mr. Forney's work will be made in the next annual volume. Mr John Nelson rendered efficient service as aid in the party.

For the fiscal year the statistics are as follows:

Triangulation:	
Area of, in square statute miles	50
Number of signal poles erected	37
Number of stations occupied for horizontal measures	22
Number of geographical positions determined	27
Topography:	
Area surveyed, in square statute miles	30
Length of general coast, in statute miles	10
Length of shore-line of creeks, in statute miles	34
Length of roads, in statute miles	24
Number of topographic sheets finished	2

These sheets were upon a scale of 1-10000, the first extending from the mouth of Santa Rosa Creek to San Simeon Bay, and the second from the mouth of San Carpoforo Creek to White Rock No. 2, south coast of California.

General charge of the land work upon the Pacific coast; the main triangulation of southern California; inspection of field parties, etc.—During the fiscal year Assistant George Davidson continued in general charge of the land work upon the Pacific coast, and has reported upon the progress of the several classes of operations incidental to and included in that assignment. He has furnished to the Superintendent general plans for the work of the coming fiscal year for the land parties, and has supplemented the instructions of the Superintendent by detailed instructions where it was deemed necessary. He has examined and reported upon the estimates of the different parties, and commends the efforts made by their several chiefs to reduce expenses to a minimum.

The summarized statements which follow relate to the various operations executed by Mr. Davidson or under his direction.

Occupation of a station in continuation of the primary triangulation of southern California.—The immediate charge of the party organized for the continuation of the primary triangulation of southern California was assigned by Mr. Davidson to Assistant James S. Lawson, aided by Subassistants P. A. Welker and Fremont Morse.

The station selected for occupation was Macho, one of the stations connecting the coast series with the transcontinental triangulation, and necessarily one in the main series that will be developed eventually over the great valley of California. The mountain is in the eastern flank of the Mount Diablo range, and overlooks the San Joaquin Valley. It lies thirty miles southeast of the town of Livermore, and is reached by wagon and by pack-animals over a rough road.

On the 22d of July, 1887, a lower camp was established in the Macho Cañon; a temporary stable for the pack-animals made, a trail up the mountain laid out, and as rapidly as possible the party and instruments were brought up to the station, which has an elevation of nearly 4,000 feet above the sea.

The piers for the theodolite and meridian instrument were made of concrete, and both were set up within the observatory, a wooden building with canvas roof. As the arrangements for observing approached completion Mr. Walker was sent to post heliotropers. At each of the stations Round Top and Conness, on account of their great height and difficulty ot access, it was deemed advisable to have two heliotropers stationed. Unfortunately, the first set of heliotropers deserted their posts a few days after being stationed, and a second set had to be sent. Assistant L. A. Sengteller performed this duty. At the stations Toro, Sierra Morena, Diablo, and Tamalpais, Mr. Charles B. Hill, who was familiar with the locality, posted the heliotropers.

For the observations at Macho the statistics reported are as follows:

Horizontal directions.—These measures were made with the twenty-inch theodolite No. 115, using it in twenty-three positions; they were begun August 19 and finished October 30. Twelve hundred and forty-five observations were made on eleven objects, in connection with sixty-one hundred and fifty-six readings of the ocular micrometer, the value of which was determined. The objects observed were eight heliotropes at stations of the triangulation, one direction mark, and the two domes of the Lick Observatory, on Mount Hamilton. Eight secondary readings (single pointings) were made on peaks in the Hamilton Range, to the north and south of the Lick Observatory.

Vertical angles.—These were observed on twenty-one days on sixteen objects by eleven hundred and eighty observations. Seven of the objects were heliotropes; the instrument used was the Gambey vertical circle No. 57.

Time.—The errors and rates of the chronometer, John Hutton, No. 207, which was used in all of the astronomical work at the station, were determined by observations on eight stars on twenty-three nights.

Latitude.—For determinations, both of time and latitude, meridian instrument No. 16 was used. For latitude, observations were made on twenty-seven pairs of stars on seven nights. Three hundred and eighteen observations upon α Ursæ Minoris were taken on six nights for value of micrometer.

Azimuth.—Observations for azimuth were made with the theodolite in the same twenty-three positions as for horizontal direction, α Ursæ Minoris being taken in twenty-two positions and δ Ursæ Minoris in six positions on twenty-two nights. In each position, ten pointings (five direct and five reversed) were made upon the mark and twelve upon the star, five hundred and thirty observations being taken.

Magnetic observations.—Determinations of the magnetic declination and horizontal intensity were made, for the former on four days and for the latter on three. After closing field-work at Macho, the standard magnetic station near the Presidio, San Francisco, was occupied. Observations for the declination and horizontal intensity were made on five days and for dip on two days.

The line from Macho to Mount Toro passed so close to the crest of the Hamilton Ridge, about two miles south and east of the Lick Observatory, that the heliotrope at Toro, when no refraction existed, showed through small oak trees and bushes. It was necessary, therefore, to remove the trees and open an avenue. At times very large refraction was noted on this line, the heliotrope at Toro appearing twice the height of the tallest trees above the ground.

An intensely smoky condition of the atmosphere prevailed in all directions, due to fires ranging over many square miles, not only in forests, but through agricultural districts, and causing great destruction. The smoke from these fires was at times so dense that only the faintest outline of ridges barely half a mile distant could be seen, and it rose to an elevation far above the line of sight to the Sierras.

After completing the field-work on October 30 the party was disbanded, and Mr. Lawson proceeded to San Francisco, where he completed his records and computations and placed them in the hands of Assistant Davidson for transmittal to Washington. In this duty he had the aid of Mr. Morse. On November 7 Mr. Welker was detached and instructed to report for duty to Assistant Sengteller.

Mr. Lawson expresses himself as indebted for very effective assistance to Messrs. Welker and Morse in all of the operations of the season.

Observations for the latitude of the Lafayette Park Station, San Francisco, in connection with the main triangulation.—The astronomical and telegraphic longitude station at Lafayette Park, San Francisco, was occupied for the observation of its latitude, in connection with the main triangulation. It was important, moreover, to know whether there existed at this station a different station error from that found at the Presidio astronomical station and Telegraph Hill latitude station, the Lafayette Park observatory having been adopted as the primary telegraphic longitude station for the Pacific coast. It is also the primary pendulum station for that coast.

It had been intended by Mr. Davidson to occupy the station for this work in October, and he prepared a large list of stars for it, but other pressing duties prevented his beginning the observations till January, 1888, when he took it up with the aid of Assistant Lawson, and at times with that of Subassistant Morse.

The instrument used was the old zenith telescope No. 1. For time, observations were made with transit instrument No. 3. The value of the zenith telescope micrometer was determined on five nights by eight sets of observations on Polaris at western elongation and on B. A. C. 4165 at eastern elongation. Each series extended through thirty-three half-turns of the micrometer screw, and observations were made at the quarter-turns to determine the mechanical defects of the shoulder and collar of the screw-bearing.

Collimator observations for value of the level scale in terms of the micrometer were made on three days.

The statistics of the work are:

Latitude:	
Number of pairs of stars observed	35
Number of nights, average	8
Whole number of observations	595
Time:	
Number of stars observed	24
Number of nights of observation	21
Number of observations	108

Occupation of the station Presidio of San Francisco for magnetic observations.—Mention has already been made of the magnetic determinations at the primary triangulation station Macho and subsequently at the station Presidio of San Francisco. At this last-named station, where Assistant Davidson began the Pacific coast series of magnetic observations in 1852, he had observations made by Subassistant Morse on five days in November, 1887, for declination and horizontal intensity, and on two days for dip. And again, by the same officer, in May, 1888, the declination, horizontal intensity, and dip were observed on four days, the object being to maintain a close watch for the epoch of maximum eastern variation.

The observations, which are very consistent, indicate that the epoch is very near at hand.

In this connection Mr. Davidson refers to his official communication of his discovery of a valuable series of magnetic variations in an old volume of Spanish explorations, in which were contained observations by the ship *Duchess of Pontchartrain*, in 1714, at nine locations between Guadalupe Island and Cape Corrientes. He has called attention also to the valuable series of magnetic observations given in Dudley's "Arcano del Mare," 1647, embracing the Atlantic coast, Gulf of

Mexico, and Pacific coast. Later, he found in the original charts of Dudley magnetic observations by Drake (1579) and by other authorities, and communicated them to the Superintendent.

Under the heading "Sub-office at San Francisco" a summary is given of the duties involved in the charge of that sub-office, which has been, as heretofore, with Mr. Davidson.

Tidal record continued at the automatic tidal station at Saucelito, San Francisco Bay, California.—Assistant Davidson has continued in charge of the Saucelito automatic tidal station, and has attended to all the tabulations and sheets, examining the latter throughout before transmitting them to the Office. The bench-mark reference to the zero of the staff has been re-examined by Mr. Westdahl, who makes monthly visits of inspection. Since Mr. Charles B. Hill resigned to accept a position at the Lick Observatory, Mr. Davidson has made the observations at the Lafayette Park station for error of the tidal chronometer. By authority of the Superintendent he furnished to Col. George H. Mendell, U. S. Engineers, the half-hourly readings of the tide-gauge for two and a half months for the reduction of his soundings in the bay of San Francisco. Mr. Emmet Gray remains as the observer at Saucelito. The record which he keeps up is of standard excellence.

Exchanges of telegraphic signals for longitude between San Francisco, California, and Portland, Oregon.—Reference was made in the last annual report to the occupation of the Lafayette Park Station, San Francisco, by the longitude parties, and the progress of the telegraphic exchanges for longitude between San Francisco and Salt Lake and San Francisco and Portland, Oregon, was stated up to the close of the fiscal year.

On July 1, 1887, Assistant C. H. Sinclair, being in charge of operations at San Francisco, and Assistant Edwin Smith at Portland, three nights of exchanges of longitude signals had been obtained. Two more were required, and these were obtained July 5 and July 8, after which the observers exchanged stations, and with Mr. Smith at San Francisco and Mr. Sinclair at Portland, the determination was completed by the exchange of longitude signals on the nights of July 18, August 12, 16, 18, and 19. The unusual length of time occupied in getting these five nights was due to very unfavorable weather at San Francisco chiefly, but partly at Portland also, and to difficulty with the telegraph lines.

During July Mr. Sinclair determined the latitude of his station on six nights, making one hundred and thirteen observations on twenty-three pairs of stars. The value of the micrometer of zenith telescope No. 2 was found by observations of ϵ and δ Ursæ Minoris at upper culmination.

It had been planned to take up the determination of a number of stations to the north of Portland, but this being deemed inadvisable on account of the lateness of the season, it was decided to take up the lines Portland–Walla Walla, Washington Territory, and Walla Walla–Salt Lake City.

A report of the progress of these longitude exchanges will be found under headings in Sections XI and XVI.

Determinations of gravity at San Francisco and at Mount Hamilton, California.—In the annual report for the preceding fiscal year an account was given of the progress of the observations for latitude and determinations of gravity made by Subassistant E. D. Preston on the Hawaiian Islands, at the request of the Hawaiian Government and by special assignment with the approval of the Secretary of the Treasury.

Under the heading "Special operations," towards the close of this volume, the further progress of that work is reported up to date of its completion, August 30, 1887, when Mr. Preston's connection with the Hawaiian Government ceased, and he sailed for San Francisco.

Having arrived at that port September 6, Mr. Preston resumed his service with the Coast and Geodetic Survey, and on the next day began preparations for the comparative determinations of gravity needed to supplement those made on the Hawaiian Islands. The first station occupied was in the pendulum-house in Lafayette Park. Some few days' delay was caused by the necessity of passing the instruments through the custom-house and of refitting the pendulum stand, which had become warped from disuse. Observations were begun September 12.

Mr. Preston acknowledges the efficient aid received from Mr. C. B. Hill, who was assigned to him for this duty through the kindness of Assistant Davidson. Mr. Hill had experience in the work, having taken part in the pendulum experiments of 1883, and with his help the swinging went on uninterruptedly night and day from the beginning to the end of the series, each observer taking eight hours' observations followed by eight hours' rest. At Lafayette Park the last swing was made September 21.

After dismounting the instruments and forwarding them to Mount Hamilton, arrangements were completed with the Director and Trustees of the Lick Observatory for the occupation of a station there. Before leaving San Francisco, barometer and thermometer comparisons were made, zero points determined, the records were duplicated, and the chronograph sheets read. These duties, with some miscellaneous office-work, occupied the time until October 9, on which day Mr. Preston left for San José, and the next day reached the Lick Observatory. Preparations for the pendulum swings were at once begun, and on the 13th instant the first observations were made. No assistance being available for continuous work day and night here as at San Francisco, the series proper, that is, twelve hours' observations per day, occupied Mr. Preston's time from 6 a. m. to about 7 p. m. daily. From 8 p. m. till midnight Mr. J. E. Keeler, assistant in the observatory, who had volunteered to aid in the work, with the approval of the Director, Prof. E. S. Holden, made one swing, and during this period observed the usual stars for time. The clock corrections furnished by the observatory, it need hardly be said, left nothing to be desired.

Observations were finished October 27, and, after dismounting the instruments and sending them to San Francisco, they were forwarded November 1 to Washington. On December 7, in accordance with instructions, Mr. Preston arrived in Washington, and took up pendulum experiments at the gravity station at the Smithsonian Institution. Reference to this work, in which he had the aid of Assistant J. B. Baylor, is made under a heading in Section III.

Resurvey of Suisun Bay and tributaries, California.—In continuation of the resurvey of Suisun Bay and its tributaries, which, as stated in the last annual report, had been brought to a close April 19, 1887, by the exhaustion of the appropriation, Assistant Louis A. Sengteller was directed on September 12, 1887, to organize a party and report to Assistant George Davidson for detailed instructions.

Pending the approval of his estimates, he took the field as directed early in October, and having recovered and rebuilt the necessary signals for the triangulation, as also the topographical signals requisite, he prosecuted the resurvey till February 2, 1888. At this date, owing to the heavy rains which had made the roads practically impassable, it was deemed advisable to close field operations.

The work had included the shore-line of Suisun Bay from the mouth of Montezuma Creek to the head of the bay; thence, passing the mouths of Grizzly Slough and Roaring River, to the passage bounded by Ryers and Simmons or Eads Islands, as also all the tributaries emptying into the bay or streams above mentioned. It was further developed from about one mile northwardly of Collinsville to the northwestward, so as to include Montezuma Creek and streams emptying therein from Grizzly Island and the main shore. The marsh and main shore-lines, and such detail beyond the latter as was found upon the old published chart or included within the area of projection furnished by the Office, were redetermined, or such portion thereof as was deemed of value to the resurvey.

For the triangulation which was needed to insure the topographical accuracy of so extended an area, the points selected were as far as practicable such structures as house-chimneys, cupolas, or gables, rapid of determination and conspicuous by their height.

After disbanding his field party, Mr. Sengteller took up the inking and tracing of his plane-table sheets, and was thus occupied until March 16, when he received telegraphic instructions from the Superintendent to resume field duty, as also detailed instructions from Assistant Davidson.

Having then re-organized his party, he resumed plane-table work March 27. At the end of the fiscal year the resurvey of Suisun Bay and its tributaries was still in progress, and it was expected would be completed in a few weeks. Up to June 30 the work accomplished included the shore-line of the bay, beginning about two miles northwardly from Benicia, up to and passing the mouth of Suisun Creek to the mouth of Montezuma Creek, where connection was made with work already done. The shore-lines of Cordelia, Suisun, Montezuma, and Nourse Creeks or Sloughs were surveyed to their heads of navigation.

For the fiscal year the statistics are:

Triangulation:	
Area of, in square statute miles	65
Number of signal poles erected	22
Number of stations occupied for horizontal measures	13
Number of geographical positions determined	18
Topography:	
Area surveyed, in square statute miles	58
Length of shore-line (Suisun Bay), in statute miles	20
Length of shore-line of creeks, in statute miles	290
Length of shore-line of ponds, in statute miles	2
Length of lines of tule and marsh, marsh and main shores	64
Length of roads, in statute miles	81
Length of dikes and ditches, in statute miles	109

Mr. Sengteller observes that the immediate shores of the bay and streams over which his survey was carried are practically of one character, being in the main composed of a line of *tule* (or bulrush) generally well defined and gradually encroaching upon former water-ways, and in many instances quite rapidly. This he found to be particularly noticeable along the shores forming the head of Suisun Bay, including the embouchures of Suisun, Montezuma, and Grizzly Sloughs, and Roaring River. Grizzly Slough, which was formerly, and within twenty years, frequented by light-draught steamers, and had a width of from one hundred to one hundred and fifty meters, is now in many places fordable, while at its mouth the *tule* has advanced one mile into the bay.

Sub-assistant P. A. Welker joined the party November 9, and served with great acceptance till January 10, when he was ordered to other duty. Mr. C. M. Allen reported for duty as temporary recorder March 23, and was still in service at the close of the fiscal year.

Resurvey of Eel River entrance and of Salt River, California.—Eel River, which is the natural outlet to the southern part of Humboldt County, California, was surveyed in 1869–'70, by Assistant A. F. Rodgers, but owing to the great changes that had taken place at the mouth of the river since that date, and the rapid development of the trade and commerce of southern Humboldt, a resurvey was demanded which should include the river from its entrance to a point about a mile and three-quarters above, and the whole of Salt River to Port Kenyon, the present shipping point for this region.

Instructions for this work having been issued to Assistant George Davidson in February, 1888, he directed Mr. Ferdinand Westdahl to make a preliminary examination of the locality and report upon the extent of the survey that would be desirable. Early in March, the plans for the work having been decided upon, Mr. Westdahl proceeded to the mouth of Eel River and began a search for the triangulation points of 1870. Although most of them had been destroyed, enough were found to determine additional ones and carry the work forward. The banks of Salt River had been surveyed in 1869 only as far as its junction with Centreville Slough, but as Port Kenyon lies nearly two miles higher up, the topography was carried up to and beyond Port Kenyon. A portion of the north and south points of Eel River entrance was also resurveyed.

After the topography was finished soundings were obtained on the bar and in the entrance, and the two rivers were sounded out to the limits of the topographical survey. The soundings were referred to a plane of reference derived from the mean of the lower low waters of twenty-seven days' observations at a tide-gauge established at the Shingle Mill Wharf, near the mouth of Salt River.

The results of the survey, both topographic and hydrographic, are shown on one projection, scale 1–20000, which has been deposited in the archives. With it Mr. Westdahl has submitted a full descriptive report of the work, which occupied him from March 12 to April 3.

Referring to the peculiarities of the streams and sloughs surveyed, he observes that Eel River is a very long stream, and in period of freshets carries a large body of water to the sea. Its delta extends from Table Bluff on the north to the hills back of Centreville on the south, a distance of eight miles, and reaches inland to the first great bend, some nine or ten miles to the ocean. In times past, the river has formed this low land and its old channels still remain as sloughs. Some of these have entirely dried up, but can be readily traced in driving across the country. The principal slough to the southward of the river is called Salt River. It is connected with Eel River, about nine miles from the sea, only in periods of freshets, when the waters of the latter river run into it by several small channels too shallow to admit the immense drift logs and snags which abound in Eel River. Salt River is, therefore, comparatively deep and free from snags and offers better facilities for shipping than the main river. Landings have been attempted on Eel River, but the steamers lose their propellers by coming in contact with sunken snags.

During the last thirty-five years the location of the entrance to Eel River has varied from a little south of its present position to about two miles to the northward. The tendency of the river during freshets or after the first rains of the fall is to break straight out opposite its mouth; as the river current becomes less voluminous, the south point keeps advancing to the northward and forcing the north point in the same direction, but with a continually narrowing opening between them. This advance to the northward, Mr. Westdahl observes, is no doubt caused in part by the general movement of the sand to the northward by the inshore eddy current, but it is also materially assisted by the shape of the junction of Salt River with Eel River. The former is at all times a tidal stream, almost equally active throughout the year, and its ebb current meets the Eel River current at right angles close under the south point of entrance, thereby tending to prolong the point.

Mr. Westdahl's report presents many statements of local interest with regard to the great progress of the region during the last ten or fifteen years, with tables showing the present value of its products, and suggestions for works of construction near the entrance to Eel River, so planned as to accelerate and make more permanent the present favorable action of the river itself.

He acknowledges the very material assistance he received from the firm of Robarts Brothers, of Ferndale and Port Kenyon, in the way of personal services and supply of means of transportation.

Upon returning to San Francisco, after having reduced and plotted his soundings and inked his sheets of survey, Mr. Westdahl resumed his regular duties in the Sub-office.

SECTION XI.

OREGON AND WASHINGTON TERRITORY, INCLUDING COAST, INTERIOR BAYS AND SOUNDS, PORTS, AND RIVERS. (SKETCHES Nos. 2, 11, 12, 17, and 18.)

Completion of the topographical reconnaissance of the coast of Oregon from Yaquina Bay to Cape Orford, and thence to Cape Sebastian.—At the beginning of the fiscal year Assistant E. F. Dickins had been in the field since the end of May, engaged in a topographical reconnaissance of the coast of Oregon between Cape Orford (formerly known as Cape Blanco) and the mouth of the Yaquina River. As stated in the last annual report, he had finished nearly one-half of this reconnaissance July 1, 1887, having at that date reached Heceta Head, on his way down the coast from Yaquina Entrance.

Intended to delineate the outline of the coast and its characteristic features, the plane-table sheets upon which the results of the work were to be shown were laid out upon a scale of 1-40000. The reconnaissance was pushed forward at every opportunity available, and by October 22 had been completed, covering five topographical sheets. These have since been forwarded to the Office, accompanied by a full descriptive report, in which Mr. Dickins makes note of the peculiarities of each portion of his survey, naming the towns and settlements, their means of communication, the facilities for navigation and the dangers thereto, and stating the distinctive topographical features of the coast line. The value of this report is much enhanced by eighteen views of capes, head-lands, and entrances included within the limits of survey.

At Blacklock Point (formerly Rocky Point) a connection was made with the topography executed by the party of Assistant Chase in 1869. Mr. Dickins checked the direction of his coast-line by observations on the sun for azimuth, at suitable intervals; approximate determinations were made also of time and latitude.

During the winter Mr. Dickins was occupied in bringing up the results of his field-work, and towards the end of March, 1888, was instructed to make a topographical reconnaissance from the limits of the topography at Cape Orford towards Cape Sebastian.

Having re-organized his party at as early a date as was desirable for the work contemplated, he left San Francisco on May 12, and proceeded by way of Empire City, Oregon, to Bandon, Koos County, on the Coquille River, where he procured saddle and pack horses, and pushed forward to Port Orford, arriving there May 24. The reconnaissance was immediately begun, but during June was greatly retarded by bad weather, sixteen rainy days occurring during that month. The party succeeded, however, in making fair progress over a very rough and rugged coast, and by June 30 had reached the mouth of the Rogue River.

The statistics of field-work for the fiscal year are as follows:

Topographical reconnaissance:	
Area of, in square statute miles (approximate)	70
Length of ocean shore-line, in statute miles	107
Length of shore-line of creeks and rivers, in statute miles	40
Length of roads, in statute miles	2
Time, latitude and azimuth:	
Number of stations occupied	3

Completion of the topographical reconnaissance of the coast of Oregon between Yaquina River and Tillamook Bay.—Examination of sites for light-houses at Cape Lookout and Cape Meares.—At the end of June, 1887, as stated in the last annual report, the topographical reconnaissance of the coast of Oregon between Yaquina River and Tillamook Bay, which had been committed to the charge of Assistant Cleveland Rockwell, had reached Cascade Head. From this point the work made good progress during the remainder of the season, and was finished August 8 on Tillamook Beach.

The general direction of the coast shown upon the topographical sheet is straight, and about west-northwest magnetic. Its topographical features are very broken and complex. The highest summits of the Coast Range of mountains are not shown upon the sheet, as they are from twelve to twenty miles back from the ocean shores. The most prominent topographical and geological features are the great transverse spur ending in Cascade Head; the high basaltic mass, terminating in the long trap dike of Cape Lookout, and the isolated mass of hills ending in Cape Meares.

Mr. Rockwell has submitted full descriptive reports of the localities of his work, accompanied by a note-book of sketches of prominent capes, headlands, and groups of rocks within the limits of his survey. These records, with the original topographical sheets, have been deposited in the archives.

While prosecuting his reconnaissance he made examinations at Cape Lookout and at Cape Meares with reference to sites for a light-house proposed to be built at one or other of these points, and has submitted a special report, with views and sketches, in which he states in detail the various considerations bearing upon the construction, facility of access, and arc of visibility of the proposed light-house, and indicates Cape Lookout as a more desirable and useful point for the purpose than Cape Meares.

During the winter, and until April 25, he was engaged on office duty, and on that date was instructed to report to Assistant Davidson at the Sub office in San Francisco, for duty in connection with the preparation for publication of the fourth edition of the Pacific Coast Pilot.

Telegraphic longitude determinations between Portland, Oregon, and Walla Walla, Washington Territory, and between Walla Walla and Salt Lake City.—Determinations of latitude and the magnetic elements at Walla Walla.—Reference has been made under a heading in Section X in this volume, to the progress of the work of the longitude parties on the Pacific slope in 1887 under the direction of Assistants Edwin Smith and C. H. Sinclair.

Exchanges of signals for longitude having been completed towards the end of August between Portland, Oregon, and San Francisco, Mr. Smith proceeded to Portland, and Mr. Sinclair to Walla Walla, Washington Territory, where he established a station in the grounds of the Court-house.

Determinations of the difference of longitude Portland–Walla Walla were made on the nights of September 5, 6, 9, 10, and 13, after which the observers changed places, and a second series of exchanges was obtained on the nights of September 15, 16, 19, 21, and 23, completing the determination.

On four days in this month Mr. Smith made observations to determine the magnetic declination, dip, and horizontal and total force at Walla Walla.

The longitude determination, Walla Walla–Salt Lake City, was taken up towards the end of September, Mr. Sinclair occupying the station at Walla Walla, and Mr. Smith the station in Temple Block, Salt Lake City. In this position of the observers, longitude signals were exchanged on the nights of September 28, October 1, 4, 8, 11, and 12.

At Walla Walla the latitude of the station was determined by Mr. Sinclair with transit No. 6, by observing twenty pairs of stars on five nights. For value of the micrometer, observations were made on 25 Camelopardalis at lower culmination.

The observers having exchanged places, the longitude exchanges needed to finish the determination of the line Walla Walla–Salt Lake City, were obtained on the nights of October 16, 17, 19, 20, 21, and 22, after which field-work was closed.

Preliminary computations show a satisfactory closing of the telegraphic circuit, Salt Lake City–San Francisco–Portland–Walla Walla–Salt Lake City.

Determinations of longitude by exchanges of telegraphic signals between Yaquina and Portland, Oregon, and between Portland and Seattle, Washington Territory.—Observations for latitude and the magnetic elements at Yaquina, and for the magnetic elements at Portland.—Early in April, 1888, Assistant Edwin Smith, having been relieved from duty at the Office, was instructed to continue the determination of geographical positions on the Pacific slope, as soon as the new transit instruments then under construction in the office could be finished. Subassistant R. A. Marr was at the same time directed to report to him to take charge of the co-operating party, and, in order to advance the work, proceeded to Yaquina, Benton County, Oregon, to get that station ready and observe for latitude and for the magnetic declination, dip, and intensity.

The longitude of Yaquina was to be determined by exchanges of telegraphic signals with Portland, Oregon. Mr. Smith left Washington May 4, after seeing to the completion of the new transits, and reached Portland May 10. At that station the weather during the month of May was very favorable, but at Yaquina quite the reverse. Towards the end of May the weather at Portland became unfavorable, and after three nights successful exchanges had been obtained, May 21, 27, and June 4, it was deemed advisable not to attempt a second series of exchanges with change of stations by the observers.

The line, Portland–Seattle, Washington Territory, was then taken up, Mr. Smith going to Seattle and Mr. Marr to Portland.

At Seattle the station established in 1886 in the grounds of the University by Assistant Gilbert was found to be in good condition. The two parties were ready for exchange of longitude signals June 11. The successful nights of exchange were June 12, 21, 22, and 24; after which the observers changed places, and in their new positions four more exchanges were obtained on the nights of June 26, 28, and 29, and July 5.

In addition to the longitude work, Mr. Marr observed at Yaquina for latitude and for the magnetic elements, and at Portland for the magnetic elements. A large number of observations were made at the three stations by both observers to determine the correction for inequality of pivots of the new transit instruments.

For the work accomplished up to the end of the fiscal year the statistics are:

Latitude, longitude, and azimuth work:	
Number of latitude stations occupied	1
Number of pairs of stars observed for latitude	77
Number of longitude stations, telegraphic	3
Longitude stations, telegraphic, number of nights of exchange of signals	10
Magnetic work:	
Number of stations occupied for observations of the magnetic declination	2
Number of stations occupied for observations of the magnetic dip	2
Number of stations occupied for observations of the magnetic intensity	2

Notice of additional stations occupied by the longitude parties will have place in the next annual report.

Topographical resurvey of the water-front at Astoria, Oregon, and recovery and remarking of tidal bench-marks.—Marked changes having taken place in the water front of Astoria, Oregon, since the survey of 1868, Assistant J. F. Pratt was directed to take up a topographical resurvey of the wharf-lines, and in connection therewith to recover and remark the old tidal bench-marks.

Upon reaching Astoria, August 21, 1887, Mr. Pratt began a search for the four triangulation stations given on a tracing of the original survey. But one of these, "Shortis House," could be certainly identified. "Astor Point" was, however, located sufficiently near for the purposes of the survey, and the work was oriented by these two stations. All traces of "Astoria flag-staff" had disappeared, and but a portion of the signal of "Upper Astoria" was found, the bluff upon which it was located having fallen away considerably.

About one-fourth of the city proper, including one-half of the business portion, is built on piles, standing over the water at high tide. Of the thirty most prominent wharves, twenty-four have been constructed for the use of the salmon canneries—the principal industry of Astoria.

Mr. Pratt calls the attention to the need of a general system governing the construction of wharves projecting into navigable waters, one that would be applicable to many localities in Oregon and Washington Territory. He observes that the channel of the Columbia River, on the Astoria side, is quite narrow, and has always been close to the shore along the water-front of the business portion of the city; it is now shoaling in front of wharves numbered 19, 20, and 21, and this, Mr. Pratt thinks, is due to the construction of the long, projecting wharves between those numbered 1 and 19.

While the topographical work was in progress, locations for the new bench-marks were selected, and all three of the old bench-marks were found. The four new bench-marks were established in localities but little likely to be disturbed, one of them (No. 4, 1887) being a copper bolt let into a basaltic bowlder buried below the surface of the ground, and another (No. 5, 1887) a copper bolt let into one of the foundation-stones of the Clatsop County jail. Descriptions of Nos. 4 and 5 were furnished to the Clatsop County court, and spread upon its minutes. All of the bench-marks were referred by careful leveling to the Coast and Geodetic Survey plane of reference, which had been determined in former years by the series of observations at the self-registering tide-gauge at Astoria. The former tidal observer, Mr. Louis Wilson, has in operation in the warehouse of his firm two tide-gauges, one of his own construction, for indicating the roughness of the Columbia River Bar, and the other, of the Coast Survey pattern, which he attends to for the Engineer officer in charge of the improvements at the mouth of the Columbia River. Field operations were closed September 6. The statistics are:

For the topography:	
Number of miles of shore-line surveyed	5
Number of miles of wharf-line surveyed	13
Number of miles of streets surveyed	8
Approximate area of survey, in square miles	2
For the tidal leveling:	
Number of series of levels	2
Number of stations to each series	18
Number of bench-marks determined	7

Soon after the completion of the work at Astoria, Mr. Pratt was instructed to resume the triangulation and topography of Saratoga Passage and vicinity. Reference to this will be again made under Section XI.

Hydrographic survey of Shoalwater Bay and its approaches, and off-shore hydrography between that bay and Gray's Harbor.—At the beginning of the fiscal year the party of Lieut. J. C. Burnett, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer *McArthur*, had been engaged in making hydrographic surveys on the Oregon coast since early in May. On July 11, 1887, the inside hydrography of Shoalwater Bay was finished, and the hydrography of the approaches to the bay, on July 28. Lieutenant Burnett then took the steamer to Astoria for coal and stores, and on August 11 began the outside hydrography between Shoalwater Bay and Gray's Harbor.

Forest fires were raging in the vicinity, and the atmosphere was so thick that but little progress could be made. During August but eight days' work could be done, and in September the weather was still more unfavorable. Heavy gales, fog, and rain prevailed and kept the vessel at anchor for nearly three weeks. There being no indication of a change of weather, and it being the opinion of pilots and others acquainted with the coast that nothing more could be accomplished during the season, Lieutenant Burnett decided to suspend further operations, and on the 10th of October returned to San Francisco.

He had succeeded, however, in developing the twenty-fathom curve from the northward of Shoalwater Bay to within two miles of Gray's Harbor. He is convinced that for work off this coast the best months are May, June, and July, with possibly a portion of August.

At the beginning of the season the officers attached to the *McArthur* were Ensigns W. P. White, J. A. Bell, and J. L. Purcell, U. S. N.; R. I. Reid, assistant engineer, and F. W. Auzal, assistant surgeon, U. S. N. Ensign N. S. Mosely, U. S. N., joined the party May 21, and Ensign J. H. Oliver, U. S. N., July 21. Ensign W. P. White, U. S. N., was detached July 24, and Ensign J. L. Purcell, U. S. N., two days later. Ensign G. R. Slocum joined the party August 7, and August 9 Ensign J. P. McGuinness, U. S. N. On the 18th of September a sad accident occurred. the upsetting of a whale-boat, by which Ensign Mosely lost his life.

The statistics of the season's work are:

Number of miles run in sounding	950
Number of angles measured	9,010
Number of soundings	40,178

Examination of Yaquina Entrance, Oregon.—In accordance with instructions issued in March, 1888, Lieutenant Burnett made an examination of the entrance to Yaquina Bay, Oregon, and found the least depth in the main channel to be 10 feet. He states that no directions can be given for entering the bay, and vessels should never attempt it without a pilot. The changes are so sudden and frequent that the pilots will not take a vessel in or out without first sounding across the bar; this they do even if they had been over it but the day before.

Upon Lieutenant Burnett's arrival off the entrance, and while waiting for high water, he made frequent casts of the lead off-shore, but could find no indications of a change in depths as given on the last published chart.

Continuation of the triangulation and topography of Saratoga Passage, and the coast and harbors in the vicinity.—Immediately after closing operations at Astoria, Oregon, reference to which has been made under a preceding heading in this section, Assistant J. F. Pratt proceeded under instructions to Seattle, Washington Territory, on his way to resume the triangulation and topography of Saratoga Passage and the waters in the vicinity. Some progress in this survey had been made by Mr. Pratt during the summer and autumn of 1886, as is stated in the last annual report.

More rapid means of transportation for the party, while on the working-ground, being needed than were available last season, Mr. Pratt has been authorized to turn the whale-boat belonging to the schooner *Yukon* into a steam-launch. Funds for this purpose being limited in amount, Mr. Pratt had himself made all the working plans and had personally superintended and directed all the details of arrangement and placing the machinery in position. After trial trips, during which the launch repeatedly made a run of sixteen miles in two hours, using as fuel drift-wood picked up on the beach, the *Yukon* was gotten under way in tow of the launch October 18, and reached the working-ground at Holmes Harbor, Washington Territory, October 24, 1887.

The triangulation and topography of the harbor were begun without delay, and prosecuted to their completion November 8. The work was then taken up in Saratoga Passage.

On November 10, during the passage of the schooner to a more favorable anchorage, an unfortunate accident occurred. The steam-launch was capsized in Saratoga Passage and sunk in thirty-five fathoms water, and the fireman drowned.

On account of the long distances that a great part of the work was from the most available anchorages, it was not now feasible to execute the topography with no other means of transportation than a row-boat; hence after the loss of the launch nothing but triangulation was attempted; this was carried on till November 29, when the advance of the season indicated that it would be advisable to close field operations.

Accordingly the *Yukon* was taken to Eagle Harbor, Puget Sound, where she was laid up, and on December 6 the party was disbanded.

The statistics of the work are as follows:

For the triangulation:	
Number of signals erected	23
Number of stations occupied	9
Number of angles measured	68
For the topography:	
Number of miles of shore-line surveyed	11
Approximate area of topography, in square miles	5

Hydrographic surveys of Saratoga Passage, Holmes Harbor, and of the northwest coast of Whidbey Island.—In accordance with instructions issued at the end of February, 1888, the schooner *Earnest* and steam-launch *Tarry-not* were prepared for hydrographic work under the direction of Lieut. H. T. Mayo, U. S. N., Assistant Coast and Geodetic Survey, and left Olympia April 10. On the 11th they arrived at Seattle, and on the 21st anchored in Holmes Harbor, Washington Territory. A tide-gauge was set up and observations begun the same day. During the progress of the hydrography, comparisons were kept up for two days of the tidal levels at Holmes Harbor with those at Tulalip on Possession Sound.

On May 31 the hydrography on the sheet of Saratoga Passage and Holmes Harbor having been completed, that of the northwest coast of Whidbey Island was taken up. Allan Island was reached June 5. The weather during the month of June was most unseasonable, and this in connection with the distance of the anchorage (necessarily four miles) from the northern limit of the work, and the difficulty of finding the old triangulation marks, led to much delay, so that up to June 30 but four days of sounding work could be done.

For the season of 1888 up to the close of the fiscal year the statistics are:

Hydrography:	
Area sounded, in square geographical miles	60
Number of miles (geographical) run while sounding	320
Number of angles measured	1,963
Number of soundings	6,265

Ensign A. C. Almy, U. S. N., was attached to the party. Mr. W. B. Edwards served as pay yeoman.

Further reference to the progress of Lieutenant Mayo's survey will be made in the next annual report.

Hydrographic surveys in Rosario Strait and Padilla Bay, Washington Territory.—The schooner *Earnest*, having been prepared for hydrographic work, under the direction of her commander, Lieut. C. T. Forse, U. S. N., Assistant Coast and Geodetic Survey, left Olympia April 14, 1887, in tow of the steam-launch *Tarry-not*. His instructions were to execute hydrographic surveys in Rosario Strait and Padilla Bay and neighboring waters.

On the 21st of April Burrows Bay was reached and the *Earnest* anchored inside Allan Island, and this anchorage upon investigation proved to be the best that could be found without going too far away from the field of work. Much bad weather was experienced till near the end of May. Even on days on which the wind was light, a heavy swell would be found in Rosario Straits, rendering it unsafe to attempt crossing with the steam-launch. A tide staff was set up and tidal observations were begun April 25. Soundings were begun May 13.

During the entire season great allowance had to be made for the tide currents. Advantage was taken of the neap-tides to execute the deep-water work, and even then it not unfrequently happened that but parts of days could be utilized.

On June 27 the schooner's anchorage was shifted to Eagle Harbor near north end of Cypress Island. A tide staff was set up and tidal observations begun the same day, an observer having been left at the Allan Island gauge to keep up observations there so that a comparison of gauges might be obtained. The sheet, which included the hydrography of Rosario Straits and Bellingham Channel, from Deception Pass Entrance to a parallel passing through Viti Rocks (omitting that portion of the straits west of Cypress Island), was finished July 30. There being a lack of signals west of Cypress Island, it was deemed advisable not to spend the time then in such triangulation as would be necessary, but to take it up later in the season.

On July 30 the *Earnest* proceeded to an anchorage on the east side of Guemes Island, near the south end, this being a central position for work on the Padilla Bay sheet. A tide staff was set up and observations begun. Smoke interfered greatly with the work during August and September, and there were occasional smoky days after the middle of October. On October 28 the hydrography on the sheet embracing Padilla, Fidalgo, and Samish Bays was completed, and further operations were suspended for the season, part of the crew being discharged on the arrival of the schooner at Seattle October 30. The reduction of the crew was completed November 5 at Olympia, and the *Earnest* laid up in winter quarters in Butler's Cove.

During the winter the party was engaged in office-work, before the completion of which Lieutenant Forse was detached from the Survey, and the records were finished by his executive officer, Lieut. H. T. Mayo, U. S. N. Lieutenant Mayo has submitted descriptive reports to accompany the two hydrographic sheets of Rosario Straits and Padilla Bay. Also the following statistics of the season:

Miles run in sounding	1,291
Angles measured	6,172
Number of soundings	32,491

Continuation of the triangulation and topography of Bellingham and Samish Bays and the islands in their vicinity.—At the beginning of the fiscal year Assistant J. J. Gilbert was actively engaged in prosecuting the triangulation and topography of Samish and Bellingham Bays, having been in the field since the middle of April, 1887. Reference to his progress from that date till July 1 was made in the last annual report.

In the first part of the season he had as a means of transportation the steam-launch *Fuca*, but by an accident to the heater of her boiler, July 12, he had to rely after that date on small boats, using sails whenever the winds were favorable. About the middle of July the usual smoky weather began, and continued with varying density until late in September, when heavy rains put out most of the forest fires. Fortunately the triangulation had been nearly completed before the smoke set in.

Starting from the base Sinclair East–Lummi Rocks, the triangulation was extended into Samish and Bellingham Bays and through Hale's Passage.

The topography executed during the season is shown on six plane-table sheets, and includes the shore-line of Guemes Island from station Boat Harbor to station Eden, and the following islands complete: Samish, Jack, Vendovi, Eliza, Point Francis, and Chuckanut; the west shore of Lummi Island as far north as Village Point station, and the east shore as far north as station Lummi northeast; also the main-land from a point near station Ware House on the Samish Flats, around the bays of Samish, Chuckanut, and Bellingham, and along Hale's Passage to its north entrance, together with about twelve miles of the Nooksacht River.

Mr. Gilbert has transmitted the records and computations of his triangulation to the archives. He has forwarded also his topographical sheets, accompanying each sheet with a full descriptive report and about twenty india-ink sketches of the localities under survey.

Tracings of the shore-line of two sheets and part of a third, with geographical positions, were furnished to the hydrographic party of Lieutenant Forse during the season.

The statistics are:

Stations occupied in triangulation	26
Number of miles of shore-line surveyed	132
Number of miles of roads and railroads surveyed	80
Number of miles of creeks or sloughs	10
Area surveyed (approximate), in square miles	63

During the winter Mr. Gilbert was occupied chiefly with office work, and before taking the field in the spring had forwarded to the office the originals and tracings of his topographic sheets and the records and computations of his triangulation. He had oversight also of the repairs made to the steamer *Fuca*. The completion of these repairs was retarded by the difficulty of obtaining materials and workmen. They were, however, finished toward the end of April, and on the 27th of that month he left Olympia for Tacoma to examine the triangulation of Commencement Bay and rectify an unexplained discrepancy.

Having found that this discrepancy was not in the observations, Mr. Gilbert proceeded to Seattle, and thence to Fairhaven. On the morning of May 4 he reached the north end of Lummi Island, where he proceeded to establish camp, preparatory to the work of connecting the triangulations of Bellingham Bay and Rosario Strait, and extending the triangulation to the Gulf of Georgia. After some time spent in searching for stations of the triangulation of 1853–'54, signals were erected on Lummi, Orcas, Clark, Barnes, Martin, Lucia, and Patos Islands, and along the main-land as far as Point Whitehorn, on the Gulf of Georgia.

Up to June 30 the triangulation had been completed as far as Patos Island, and the work was in active progress. The topography was but just begun; some had been done on Lummi Island and up the Lummi River, and some on Sandy Point.

Further reference to this survey will be made in the next annual report.

SECTION XII.

ALASKA, INCLUDING THE COAST, INLETS, SOUNDS, BAYS, RIVERS, AND THE ALEUTIAN ISLANDS.

(SKETCH No. 13.)

Hydrographic surveys in Frederick Sound and vicinity, southeastern Alaska.—Under instructions dated in March, 1887, Lieutenant-Commander Charles M. Thomas, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer *Patterson*, left San Francisco May 4, for Alaska. The *Patterson* had in tow the new steam launch *Cosmos*, which had been constructed at the Mare Island Navy-yard. In immediate command of the *Cosmos* was Ensign A. P. Niblack, assisted by Ensign A. M. Beecher, U. S. N., both attached to Lieutenant-Commander Thomas' party. Other officers under his command were Lieut. De Witt Coffman, U. S. N.; Ensigns Albert N. Wood, John H. Shipley, Charles C. Marsh, Maurice L. Read, and John D. McDonald, U. S. N.; Thomas H. Streets, Passed Assistant Surgeon, U. S. N., and Holland N. Stephenson, Passed Assistant Engineer, U. S. N. Mr. John McHenry holding the rate of paymaster's yeoman, and Mr. J. C. Stone holding the rate of master-at-arms, were employed as draughtsmen.

Port Townsend, Washington Territory, was the first port to be made on the trip. The voyage proved to be a very tempestuous one. While passing through a severe gale on May 7, off Cape Gregory, the hawser used in towing the *Cosmos* snapped, and the two vessels parted company, the *Patterson* reaching Port Townsend May 11, and the *Cosmos* on the night of May 12.

Ensign Niblack has made a full report of the voyage of the *Cosmos* up to the date of her joining the *Patterson*. At the outset, when the hawser broke, one of the firemen was disabled, and while crossing the bar of the Columbia River, through three miles of breakers, a heavy sea made a clean breach through the deck-house, flooded the engine-room and galley, broke the water gauge, and stopped the engine. The machinist, Maurice Golden, though bruised and stunned, stuck to his post, and by his coolness and bravery, further damage to the launch was prevented, and she was enabled to steam under the lee of a pilot tug, and so was shielded from the terrible force of the seas. At Astoria, Lieutenant Burnett, U. S. N., commanding the steamer *McArthur*, rendered every assistance; coal and water were obtained, and early in the morning of May 11 the *Cosmos* followed the *McArthur* across the bar. That evening, off Destruction Island, a fishing schooner was sighted, showing signals of distress, and upon standing down to her it was found that she had on board the ship-wrecked crew of the four-masted ship, *Ocean King*, bound from Nanaimo to San Pedro with a load of coal. This ship had foundered in the gale off Cape Gregory on May 8. The captain, two mates, and her crew of twenty-two men were taken off by the *Cosmos* and landed at Port Townsend.

Ensign Niblack, to whose excellent seamanship and good judgment the launch owed her safety, expresses his high appreciation of the services rendered by Ensign Beecher in supporting his own efforts to bring the launch through. After the accident to the fireman, Mr. Beecher stood an engine-room watch, with one of the seamen as fireman, alternating with Mr. Golden.

After taking on board signal lumber at Hadlock, Washington Territory, and coaling at Departure Bay, the *Patterson* arrived at Port Simpson, British Columbia, May 21. Here Ensign C. C. Marsh, U. S. N., the astronomer of the expedition, obtained observations for time. In order to expedite the prospective season's work, Lieutenant-Commander Thomas fitted out the *Cosmos* with ten days' supplies and sent her with Ensign Niblack in charge, Ensign Beecher assisting, to Frederick Sound, with instructions to reconnoiter for the site of a base-line, and select one near Dry Strait.

On May 25 the *Patterson* was at Fort Wrangell, and Ensign Marsh was directed to occupy the astronomical station established at North Base station by Lieutenant-Commander Snow in 1886. On May 26 the steamer was anchored in Frederick Sound, near the north end of Wrangell Narrows, finding the *Cosmos* there.

The site for a base that had been selected did not meet all of the requirements for a good connection with the triangulation; accordingly, the steam-launches, *Cosmos*, *Vixen*, and *Pirate*, with Lieutenant Coffman, Ensign Wood, and Ensign Read, respectively, in charge, were engaged on May 27, 28, and 29 in searching for a suitable site, and one was finally found by Ensign Wood on the eastern shore of the Sound, back of Point Agassiz, which, after personal inspection by Lieutenant-Commander Thomas, was adopted. The whole length of this base being over a level stretch of ground above high water, it was readily capable of accurate measurement. Of two measurements, made carefully with piano wire, the mean was taken, 4,609.35 meters, equal to 2.86 statute miles.

On May 31 the steamer's anchorage was shifted to Brown Cove, in order to be near the astronomical station which it was decided to establish at South Base station. On June 1 a tide-gauge was put up near the anchorage, and tidal observations for a full lunar month were begun under the supervision of Lieut. De Witt Coffman, U. S. N. Other gauges subsequently put up at Portage Cove, Duncan Canal, Woods Bay, north end of Dry Strait, and at Fort Wrangell were connected with this one by simultaneous observations, but slight differences of tidal level being shown.

Upon the completion of his observations for time at station Wrangell, North Base (1886), Ensign Marsh began on June 4 the determination of the astronomical position of the Frederick Sound station, South Base, finding it to be by his field computations in latitude $56° 55' 44''.7$ N. and in longitude $8^h 51^m 24.5^s$ west of Greenwich. The magnetic variation, as determined by compass magnetometer No. 15, was found to be $29° 40' 28''$ E. of N.

A check-base, 250.28 meters in length, was measured June 4 on the Soukhoi Islands.

On June 12, the *Cosmos* was despatched to Union Bay, Clarence Strait, to convey thither Ensign Marsh, with instructions to occupy the astronomical station established there in 1885 by Lieut. Richardson Clover, U. S. N., and thence to proceed to Port Simpson, British Columbia, to get additional observations for time. Delay occurred, owing to continued bad weather at Port Simpson, so that it was not till June 25 that time could be determined. Next day Ensign Marsh re-occupied the Union Bay station, and returned to Brown Cove on the 27th.

Meantime, the triangulation was continued by Ensign Niblack, using the steam-launch *Vixen*, and Ensign Read, with Mr. John McIlenry, in the *Pirate*, continued the running in of shore-line on the working ground. A plane-table sheet of Brown Cove was executed by Mr. Stone between June 7 and 11.

Leaving a tidal observer in camp at Brown Cove, Lieutenant-Commander Thomas on June 20 shifted his anchorage to Portage Bay, Kupreanoff Island, where a tidal station was established, a check base of six hundred and twenty meters in length measured; a topographical survey made, and a magnetic station occupied, the variation being found to be $30° 29' 16''$ easterly. Ensign Marsh was sent to Cape Fanshaw, where he established an astronomical station, and determined its geographical position in latitude 57° 11′ 04″.4 N., and longitude 8^h 54^m 16.1^s west of Greenwich. For the magnetic variation he obtained 30° 06′ 31″ E. of N.

On July 13, the *Cosmos* was fitted out with supplies and signal lumber, and sent with whale boat in tow in charge of Ensign Wood, with Ensign Beecher as assistant, to conduct the survey of Duncan Canal, which opens into Sumner Strait between Woewodski and Kupreanoff Islands. A check base-line of 1,747.59 meters was measured and an astronomical station established at East Base station, observations at which showed its geographical position to be in latitude 56° 35′ 47″.8 N., and longitude 8^h 52^m 25.3^s west of Greenwich. The magnetic variation was 30° 03′ 34″.3 E. of N. Tidal observations were made for a length of time sufficient to connect with those at Portage Bay, the difference of readings proving to be very small.

The soundings on the northern portion of the projection sheet in the vicinity of Cape Fanshaw were put in by a party on the *Cosmos*, between August 7 and 26, Ensign M. L. Read being in command and Ensign J. D. McDonald assisting.

On the 8th of August the *Patterson* shifted her anchorage from Portage Bay to Thomas Bay, in entering which great caution was observed, Lieutenant-Commander Thomas keeping two leads going on his own vessel, and sending ahead the steam launches *Vixen* and *Pirate* to sound as rapidly as possible in advance.

An anchorage of seventeen fathoms in the southern arm of the bay was obtained near a fine waterfall, a tide-gauge established near the ship, and on August 11 a check base of 1,357.9 meters in length was measured at the foot of Baird Glacier, in the northern arm of the bay. Determinations of geographical position at East Base gave for the latitude 57° 06′ 38.″3 N., and for the longitude 8^h 51^m 12.2^s west of Greenwich.

The survey of Thomas Bay was finished August 19. After receiving an additional supply of coal from the Pacific Mail Company's steamer *Idaho*, operations were continued till the close of the season in October, by an independent survey of Duncan Canal, by the completion of the work in Union Bay, connecting with the survey made there in 1886 by Lieutenant-Commander Snow, and by the search for and location of a rock with a least depth upon it of nine feet in Nakat Inlet, off Tongass Island. The rock was located October 8, and information in regard to its position was published in Notice to Mariners No. 92, bearing date of October 31.

Of the work accomplished by Lieutenant-Commander Thomas and his party, the statement above made is simply an abstract, taken from the exceedingly interesting and valuable report submitted by that officer, in which he gives full descriptions of the country included in the limits of his survey, its harbors and anchorages, and its striking natural features. Among these are the Great Baird and Patterson Glaciers, the Le Conte Glacier, and the Horn Cliffs. Upwards of one hundred photographic views illustrate the report; they were taken by Ensign Niblack and Mr. McHenry. Mr. Niblack had been for three seasons the photographer in the *Patterson's* party.

After concluding the search at Fort Tongass, the *Cosmos*, with Ensign Marsh, was sent to Port Simpson, British Columbia, where final observations for time were obtained by that officer on the night of October 8.

October 13, after placing the *Cosmos* in winter quarters, the *Patterson* left Port Simpson for San Francisco, stopping at Departure Bay and Port Townsend, and arriving at San Francisco October 23, after a passage from Port Townsend of four days and seven hours.

The results of the season's work are shown upon the following hydrographic sheets:

1. Three sheets, Frederick Sound, S. E. Alaska, from Dry Strait to Cape Fanshaw. Scale, 1–80000.

   The first of these is the completed hydrographic sheet; the second shows the triangulation executed; the third shows the rough plotting of the soundings.
2. Duncan Canal Entrance. Scale, 1–20000.
3. Duncan Canal, middle part, including connection with Wrangell Strait. Scale, 1–20000.
4. Duncan Canal, upper part. Scale, 1–20000.
5. Brown Cove, Frederick Sound. Scale, 1–5000.
6. Thomas Bay, Frederick Sound. Scale, 1–20000.
7. Farragut Bay, Frederick Sound. Scale, 1–20000.
8. Portage Bay, Frederick Sound. Scale, 1–10000.

The statistics of the survey are as follows:

Number of triangulation points occupied	364
Number of angles observed	8,951
Number of miles of shore-line surveyed	624
Approximate area of country surveyed in square miles	1,740
Number of miles of sounding lines run	1,992
Number of angles observed	14,475
Number of soundings	11,536
Number of positions occupied for observing currents	160
Number of stations at which observations for azimuth were made	4
Number of stations at which observations for latitude were made	4
Number of stations at which observations for longitude were made	7
Number of pairs of stars observed for latitude	164
Number of sets of observations made for magnetic declination	28
Number of sets of observations made for magnetic dip	13
Number of sets of observations made for magnetic intensity	17

Lieutenant-Commander Thomas expresses his thorough satisfaction with the manner in which all the members of his party performed the duties intrusted to them, referring particularly to the zeal, ability, and untiring industry shown by Ensigns Wood and Beecher in making an independent survey of Duncan Canal, a work which they volunteered to do; also, to the work of Ensign Niblack, whom he placed in charge of the main triangulation. He feels it incumbent upon him to call special attention to the astronomical work of Ensign Marsh, involving as it did frequent absences miles away from the ship, under circumstances of much personal hardship and many difficulties, which were speedily overcome by the ingenuity and skill of that able officer. All of the members of the party took part in sounding, but the greater part of the hydrographic work was done by Ensigns Wood, Read, Beecher, and McDonald.

The triangulation of Portage Bay, measurement of base, and plane table work was executed by Mr. J. C. Stone, draughtsman. Lieutenant-Commander Thomas deems the harbor sheet of that locality highly creditable to Mr. Stone, it being the result of his own labor without assistance except the soundings. The shore-line on the projection sheet of 1887, with the exception of Duncan Canal, Beecher Pass, and Cleveland Passage, was run in by Messrs. McHenry and Stone, the former using a sextant and establishing points between stations, then sketching in the shore between these points; the latter using a plane-table exclusively. Ensign McDonald delineated the shore-line of Cleveland Passage and Whitney Island.

Full details are given in the report with regard to the courses of the flood and ebb tides in Frederick Sound and the waters which connect with it, the set and velocity of the currents, the rise and fall of the tides, and the comparative times of high water. Lieutenant-Commander Thomas observes that the time of high water, as also the rise and fall of the tides, is practically the same over the entire body of water included in the limits of his survey. At Cape Fanshaw high water is about seven minutes later than at Fort Wrangell.

About the middle of March, 1888, in pursuance of general instructions previously issued by the Superintendent, detailed instructions were forwarded to Lieutenant-Commander Thomas by the Hydrographic Inspector relative to his work in Alaska for the coming season.

He was directed to take up the hydrography from the northern limits of the survey of 1887, extending it up to Stephens Passage, and over to the westward into Frederick Sound far enough to include Turnabout Island, and any other prominent features that would be of use to vessels standing up Stephens Passage.

The *Patterson* left San Francisco April 7, 1888, and reached her working ground April 27. The surveys begun by Lieutenant-Commander Thomas were in active progress when it became necessary to interrupt them, and instruct him to proceed to Portland Canal and Pearse's Channel, and take up a general survey in those localities in order to comply with a request from the Department of State for surveys required to furnish data for a determination of the boundary line between Alaska and British Columbia.

In accordance with these instructions he left for Portland Canal towards the end of June, and arrived with his party at Port Simpson, British Columbia, on July 2, 1888.

Full statements, giving details of this work and of that previously executed in Alaska, are necessarily deferred till the next annual report.

Continuation of tidal record at the automatic tidal station at St. Paul, Kadiak Island, Alaska.—The series of tidal observations with an automatic tide-gauge at St. Paul, Kadiak Island, Alaska, has been kept up as heretofore under the general supervision of Assistant George Davidson. Mr. Fred. Sargent remains as observer.

Mr. Davidson expresses his obligations to the Alaska Commercial Company for transmitting all official correspondence to and from this distant station with which there is no regular mail communication, and in winter no communication whatever. Lieutenant-Commander H. E. Nichols, U. S. N., Assistant Coast and Geodetic Survey, and Lieutenant-Commander W. H. Emory, U. S. N., commanding the steamer *Thetis*, and other officers have inspected the station, and have given the observer the local time to check his chronometer.

All of the records show care and attention, and have been duly transmitted to the Office.

Hydrographic explorations in western Alaska.—In pursuance of the assignment of Lieutenant-Commander H. E. Nichols, U. S. N., Assistant Coast and Geodetic Survey, to the duty of preparing a revised edition of the Coast Pilot of Alaska, and in order to obtain additional data for that work, he was instructed to proceed to western Alaska in March, 1888, availing himself of the Alaska Commercial Company's steamer, leaving San Francisco on the 10th or 20th of that month for Kadiak, and thence to Unalashka.

Lieutenant-Commander Nichols was not provided with an equipment for surveying work, the object of his expedition being to make such notes and observations as would enable him to add to, or correct approximately, the existing charts, prepare descriptions and sailing directions, and take views either by pencil or photograph. In the rapid movements that he was compelled to make, he found the pencil of more general use than the photograph on account of the prevalence of mist and fog. Even when the observer can sketch through fog, the photographic apparatus is often of no use.

In accordance with instructions, he left San Francisco in the steamer *St. Paul* of the Alaska Commercial Company, March 22, and arrived at St. Paul Harbor, Kadiak Island, on April 3. He was unable to visit any other part of the island, but makes note of an addition required by the chart of that harbor; it should show Cape Chiniak, the point always made in coming from the southward or eastward. He succeeded in getting a photograph of this point, and remarks that Tebenkoff's view is also very good. From shipmasters and others in the employ of the company he obtained some information respecting Karluk Straits.

From Kadiak he proceeded to Unalashka, which place he made his headquarters during the summer, and from which he availed himself of every opportunity to visit the surrounding country, taking passage as occasion offered on the vessels of the Alaska Commercial Company on their trips to the various trading stations.

On Unalashka Island, he visited Makushin, Kashega, and Chemoffsky; also Unimak, on Unimak Island. These places are inhabited only by the native Aleuts, the company having a trading station at each place. Atkha, Kyska, and Attu, on islands of the same name, were successively visited; also Akutan, on Akutan Island.

Outside of Bering Sea he visited Sannakh Island, Belkoffsky, Wossensensky, and Unga, some of them more than once, at the same time acquiring information regarding surrounding places as he passed in their vicinity, and taking views and sketches where practicable and useful.

His examinations, which are detailed at length in his report, extended to the westernmost islands of the Aleutian chain, and included also the Pribiloff or Seal Islands, some localities in Bristol Bay, the Shumagin Islands, and the east coast of the Alaska Peninsula.

For the practical interests of the navigator, Lieutenant Commander Nichols deems sufficient the knowledge of the tides acquired during several years' observations at the St. Paul station, and recommends that its removal to a more important locality should be considered.

Among the localities specially demanding investigation and survey he mentions the whole of the east coast of the Peninsula of Alaska, the rivers emptying into Bristol Bay in Bering Sea, the delta of the Yukon, the eastern half of Bering Sea south of Norton Sound, and the Passes leading to the Pacific Ocean.

In concluding his report, Lieutenant-Commander Nichols expresses his conviction that the present and increasing commercial interests of western Alaska warrant a request for the construction of vessels specially adapted for making surveys of its waters. To the Alaska Commercial Company and its employés he acknowledges his obligations for many courtesies, and the tender of every facility possible for carrying on his work.

SECTION XIII.

KENTUCKY AND TENNESSEE. (SKETCHES NOS. 1, 6, 15, 17, AND 18.)

Extension westward of the transcontinental triangulation near the thirty-ninth parallel in Kentucky and Ohio.—At the beginning of the fiscal year, the party under the charge of Assistant A. T. Mosman, engaged in continuing to the westward the transcontinental triangulation in Kentucky and Ohio, were occupying station Ash Ridge, Brown County, Ohio, and had nearly finished work there. Mr. R. J. Meigs (No. 3) joined the party as recorder June 30, 1887. The building party under Foreman E. E. Torrey was erecting a fifty-foot signal at station Stevens, Kenton County, Kentucky, after completing which he joined the main party July 5.

The necessary observations at Ash Ridge station were finished July 5, and the party was then transferred to station Minerva, Mason County, Kentucky, about ten miles northwest of Maysville. The theodolite and observing tent having been set up on the tripod, observations for horizontal directions were begun on the 10th of July and finished on the 31st. During this period a temporary observatory was erected near the station, and meridian telescope No. 7 was mounted to be used for determining time, while zenith teloscope No. 6 was set up for latitude determinations.

The observations for time and azimuth were assigned to Mr. W. B. Fairfield, Extra Observer, who had joined the party on July 29; those for latitude were made by Mr. Mosman. Cloudy nights and fog over the Ohio River delayed the work somewhat, but all of the observations were completed by August 30; after which, station Tate, Clermont County, Ohio, was occupied. The observing tripod at Tate was one hundred and twenty-nine feet high, and required considerable labor to prepare it for the work, wire guys having to be rigged, and tackle for setting and furling the canvas screens made and adjusted. Observations at Tate were begun September 8. Very unfavorable weather prevailed, and additional delay was caused by the prevalence of fresh winds during which the tremor communicated to the tripod made it impossible to obtain satisfactory pointings. While at Tate station, a signal one hundred and thirty-two feet in height was built at station Tanner, Boone County, Kentucky, about ten miles southwest of Covington, and the line to it from Tate opened.

After the completion of work at Tate Station, the party was divided in order to facilitate progress. Messrs. Mosman and Torrey proceeded to Stevens station, about eleven miles south of Covington, Kentucky, while Messrs. Fairfield and Meigs occupied Flaughn Station, about nine miles northeast of Falmouth, Pendleton County. Very smoky, dry weather delayed the work, making it impossible for days at a time to see more than four or five miles. Station Stevens was finished November 5, but Mr. Fairfield was detained at station Flaughn till December 8.

After testing the intervisibility of the line Tanner to Dry Ridge, Mr. Mosman was occupied till November 19 at Portsmouth, Ohio, in organizing a board for the examination and sale of certain camp equipage and other property of the Survey which had been stored there. Due report of its disposition having been made, he reported at the Office November 21, and was subsequently ordered to Office duty in bringing up the records and computations of his season's work, Mr. W. B. Fairfield aiding him.

The statistics of the season are as follows:

Number of signals erected	2
Number of stations occupied	5
Whole number of observations of horizontal directions	2,877
Number of stars observed for time	187
Number of pairs of stars observed for latitude	16
Number of observations for azimuth	384

Upon the completion of his records and computations for the archives, Mr. Mosman was assigned to other Office duty, and on April 30, 1888, was relieved from the Office and instructed to take up a triangulation upon Long Island from Montauk Point westward.

Geodetic operations.—Occupation of stations for the connection of the triangulation of the State of Tennessee with the primary triangulation of the Coast and Geodetic Survey in northern Georgia and Alabama.—The connection of the triangulation of the State of Tennessee with the primary triangulation in northern Georgia and Alabama was advanced during the season of 1887 by Prof. A. H. Buchanan, Acting Assistant, who occupied four stations, Deadening, Owen, Roy, and Bean, of the scheme which he had laid out the previous season in pursuance of suggestions made by Assistant C. O. Boutelle, in immediate charge of State surveys.

The occupation of a fifth station, Harvey, was begun and about two-thirds completed. It had been Professor Buchanan's intention to finish Harvey station and push on to High Point, in northern Alabama, but he was delayed at Bean station by bad weather about two weeks, and in July the signal at High Point was entirely destroyed by lightning. Bean station was finished August 29, and on the same day Professor Buchanan started for Harvey station. Hoping to get through with all the observations at that point by September 15, he stationed heliotropers at all the primary points, five in number, believing this to be a measure of economy. They were directed to begin showing September 3, and continue ten days.

Delays in mail transmission and delays owing to smoky atmosphere combined to prevent the entire success which should have attended the constant watch kept up by Professor Buchanan, who was at the theodolite from sunrise to sunset every day. Finding that there was no prospect of finishing the station during the season, he decided to postpone further work at Harvey till the following spring, and left the field September 19.

About the middle of June, 1888, he resumed the work in accordance with instructions, and at the date at which this report closes was actively engaged in its prosecution.

SECTION XIV.

OHIO, INDIANA, ILLINOIS, MICHIGAN, AND WISCONSIN. (SKETCHES NOS. 1, 14, 15, 17, AND 18.)

Extension to the westward of the transcontinental triangulation near the thirty-ninth parallel in Ohio and Kentucky.—The advance to the westward made in the primary triangulation near the thirty-ninth parallel by the occupation of stations in Ohio and Kentucky was reported under a heading in the preceding section. As there stated, Assistant A. T. Mosman was in charge of the party, aided by Extra Observer W. B. Fairfield, R. J. Meigs, Recorder, and E. E. Torrey, Foreman. One of the highest observing tripods ever erected was occupied during the season, that at station Tate, Clermont County, Ohio, having an elevation of one hundred and twenty-nine feet.

Field operations were closed early in December.

Reconnaissance for the connection of the triangulation of the State of Indiana with the transcontinental triangulation near the thirty-ninth parallel, advancing to the eastward in Indiana, and to the westward in Kentucky.—The near approach of the two branches of the transcontinental triangulation, one advancing to the westward in Kentucky, the other to the eastward in Indiana, made it desirable to have a reconnaissance executed which should establish a satisfactory scheme for the connection of these two branches, and which should at the same time connect the trigonometrical survey of the State of Indiana with the transcontinental triangulation in that State.

This duty was intrusted to Assistant F. W. Perkins, under instructions issued in July, 1887. Mr. Walter B. Fairfield, Extra Observer, who was assigned to Mr. Perkins's party, took the field in advance of his chief, and had practically completed the first figure eastward from the line Bariden–Leonard in Indiana by the 23d of July. The final selection and verification of the points of this figure, and the erection of a tripod at Weed Patch station were completed by August 15. It was necessary to build this tripod before proceeding further on account of an obstructing ridge which lies about eight or nine miles to the eastward, and through which the gaps are few and very narrow.

The southeast point, Miller, was unfortunately masked in like manner by a cluster of knobs lying about three miles to the northeast.

These two ridges and the Finley Knobs mark the eastern edge of the sandstone formation, and stand four or five hundred feet above the plain to the eastward. This plain, which embraces the whole drainage of the Vernon and Graham Forks of the Muscatatuck River, and the greater portion of the White or Driftwood River, covers about fifty minutes of longitude, or the whole width of the Niagara limestone. It rises pretty regularly from five hundred feet above mean tide at the west to about one thousand feet at its eastern edge, where the formation changes to the Cincinnati limestone, and the drainage tends westward to the Ohio River.

The White and Muscatatuck regions are said to be the most heavily wooded in the State. The original growth must have been among the finest in the Mississippi Valley, since, after repeated cutting, many trees remain which range from one hundred and twenty to one hundred and thirty feet in height, and the average is not less than one hundred.

Upon the broad highlands the land is so flat that the water remains upon the surface during the greater portion of the year, excepting in those places where some kind of drainage has been attempted, and as this practically confines farming operations to the vicinity of the streams, it accounts for the plateaus being so heavily wooded.

In the eastern section, which is drained directly into the Ohio, a much larger proportion of the land is under cultivation, and the woodland is proportionately small, while on the Kentucky side of the river, as far east as the dividing ridge, upon which Tanner and Dry Ridge stations stand, the country has been almost denuded of trees.

Owing to the conditions stated above, together with the fact that the streams have very shallow and narrow valleys, extremely high signals are rendered necessary, and also, in some instances, the cutting of more or less trees.

Immediately eastward from the line Weed Patch-Miller, and westward from Tanner–Dry Ridge, Mr. Perkins adopted a series of very long four-sided figures, with central points, which join on a hexagon of good proportions. For this scheme, with the length of lines involved in it, the signals will seem excessively high, but the profile roughly suggested by the description of the surface, which is a very flat **W**, will show the necessity of having them so.

The connection with the State survey is by the line Finley-Miller, which forms with Noon-Stout a well-shaped quadrilateral.

The season was one of extreme drought in the region examined, resulting in very unfavorable atmospheric conditions, which with the long lines made the work of verification very tedious. An attempt which was made to shorten the lines in the western part of the work soon showed that the only result would be to multiply the number of the signals without materially reducing their height.

Extension of the transcontinental triangulation near the thirty-ninth parallel to the eastward in the State of Indiana.—In the last annual report a statement was given of the progress made up to June 30, 1887, by the party in charge of Assistant George A. Fairfield, engaged in occupying stations for extending to the eastward in Indiana the transcontinental triangulation near the thirty-ninth parallel.

At Osborn station, Martin County, Indiana, the final observations for azimuth needed to complete the work there were obtained July 2. The next station occupied was Rariden, which is about three miles northwest of Mitchell, Lawrence County, Indiana. The reconnaissance for the selection of additional stations to the eastward being still in progress, and the completion of the next figure having not then been reported, observations could be made on the back stations only. The night signal lamps having been previously established at these stations, observations on them were completed July 17, and while waiting for the reconnaissance and construction parties Mr. Fairfield connected a section stone on the Second Principal Meridian with the triangulation, and determined the height of Rariden station above the bench-mark in Mitchell, Indiana, which had been established by Assistant Braid in his line of transcontinental leveling of precision.

The section stone was found with the aid of the county surveyor of Lawrence County, but its position was such that it could not be seen from any of the primary stations; hence it became necessary to interpolate two stations, one of which was established on the school-house at Bedford, the county seat of Lawrence County.

At the two secondary stations the observations were made by Mr. F. H. Parsons, Subassistant, who was attached to Mr. Fairfield's party. He determined also the difference of elevation between Rariden and the bench-mark at Mitchell by running lines of leveling forward and back, a distance of three miles, with an ordinary engineer's Y level. The two determinations agreed very closely.

On July 23 Mr. W. B. Fairfield, who had been temporarily detached for reconnaissance duty, rejoined the party, and reported that he had obtained for the next figure to the eastward a quadrilateral with a central point, and that he had selected the three stations Fountain, Miller, and Weed Patch.

Mr. Torrey, Foreman in charge of the construction party, was at once directed to build a tripod and scaffold signal eighty feet high at Miller station, and another one hundred and six feet high at Fountain Station.

Mr. W. B. Fairfield, having left full notes of his reconnaissance, was relieved from further duty with the party and started on the 26th to join the party of Assistant Mossman, as had been before arranged.

On August 15 the eighty-foot signal at Miller station was completed and the signal lamp was lighted. Next day the construction party moved to Fountain station and began the erection of the high signal there.

Observations on Miller signal were finished August 25, and those on Fountain signal, begun on the 31st, were completed September 5. At Weed Patch station a temporary structure sixty-five feet high had been put up by Assistant Perkins for reconnoitering purposes, and this was found sufficiently stable to be used as a station for a signal light. The erection of an observing tripod and signal at Weed Patch was deferred, therefore, to another season.

From Miller and Weed Patch stations a magnesium light was shown during several days in August by Mr. Parsons to Mr. Perkins' reconnaissance party.

After the completion of observations at Rariden station Beard was next occupied. It is about six miles southwest of Harrodsburg, Monroe County, Indiana, a town on the Louisville, New Albany, and Chicago Railroad. Between September 14 and October 1 all of the observations at Beard were finished. These included pointings on six regular signal lights besides those for connecting with the Second Principal Meridian.

The party was at once transferred to Leonard station; everything was made ready to observe there by October 9, and on the 19th work at the station was finished without having missed a light in any of the seventeen positions, a feat which Mr. Fairfield observes he had never been able to accomplish before.

By October 29 all arrangements had been completed for beginning observations at Fountain station, and on November 13 they were finished, after which field operations were closed for the season and the party disbanded.

The weather was for the most part very unfavorable for the work. For several months no rain fell at all; consequently the air was filled with clouds of dust; this combined with the coal smoke, which is always present in vast quantities in the atmosphere of Indiana and Illinois, and made it difficult to see the signal lights at night on long lines.

Nearly all the wells in the country gave out, and many of the farmers had to haul water for several miles for their stock. During July and August the heat was intense, the mercury frequently rising as high as 105° in the shade, and on one or two occasions marking 112° inside of Mr. Fairfield's tent. Later in the season the smoke from the numerous and extensive forest fires that were raging over all parts of Indiana and Illinois gave much annoyance. For a week at a time it would be so dense as to obscure even the faintest outlines of a large grove of trees, one hundred feet high and not more than a quarter of a mile off. The amount of work accomplished despite these unfavorable circumstances is exceedingly creditable to Mr. Fairfield and the members of his party.

During the entire season he used to illuminate the axis of the telescope a small Edison incandescent lamp of three-candle power, run by one of the small B batteries made by the Stout Meadowcroft Company, of New York. This was found to give a very fair light for the purpose, being steady, easily graduated to intensity by the prismatic mirror, and of course without any flickering from the wind. During part of the time he employed also, as reading lamps, small electric hand lamps, run by the same battery, but the light was so intense and made such sharp shadows that unless it was always held in the same position with reference to the reading microscopes there was danger of getting a wrong reading. The use of these was abandoned, therefore, and that of the ordinary bull's-eye lanterns resumed.

The statistics for the season since July 1, 1887, to the close of field operations, are as follows:

Number of primary stations selected	3
Number of secondary stations selected	3
Number of primary signals built	2
Number of secondary signals built	3
Number of primary stations occupied	4
Number of secondary stations occupied	2
Number of observations for horizontal direction	2,366
Number of miles of leveling run	6

During the winter Mr. Fairfield was engaged in office work. He will continue work on the transcontinental triangulation at the earliest date practicable.

Topographical survey of the site of the American Bottom Base, Illinois.—A remeasurement of the base-line in the Great American Bottom in St. Clair and Madison Counties, Illinois, having become desirable, Subassistant J. E. McGrath was directed to make a topographical survey of the site of the base, and a preliminary measurement of its length.

He began field operations for this purpose March 10, and completed them March 31, 1888.

After erecting signals at both ends of the base, the line was cleared of brush and was then measured with a steel tape, stubs being driven in every fifty feet, having copper nails in their tops to indicate each section of fifty feet. Spirit-levels were then run over the line and cross-sections made at all points where it was necessary to develop the contours. Data were thus obtained from which to make a profile of the base site and a topographical map.

The country through which the line runs is very low, flat, and difficult to drain. The original measurement was made in 1872.

Other duty executed by Mr. McGrath is referred to in Sections II, VIII, and XV.

Geodetic operations continued in the State of Wisconsin.—The party organized by Prof. John E. Davies, Acting Assistant, for the continuation of the triangulation of the State of Wisconsin, took the field, under instructions, about the middle of May, 1887, and began observations at Lowell station near Reeseville, Dodge County. This station had been occupied in 1886 in order to make certain examinations needed to perfect the reconnaissance for extending the triangulation to the eastward and southward.

Upon the completion of the observations at Reeseville, Professor Davies transferred his party to station Fitzsimmons near the town of Baraboo, in Sauk County, and was occupied there till the advance of the season compelled a cessation of field operations. Fitzsimmons was occupied also as an astromomical station by Assistant C. O. Boutelle, as is stated under the next heading in this section.

At Reeseville, Professor Davies measured thirty-one angles by three hundred and seventy-two repetitions. He put up new signals at the stations Elephant Bluff, Observatory Hill, Devil's Lake, and Gibraltar Bluff, and prepared the new tripod and observing scaffold at Fitzsimmons station.

Observations for latitude and azimuth at a trigonometric station in Wisconsin.—Upon the conclusion of his duties in Minnesota, reference to which is made under a heading in Section XV, Assistant C. O. Boutelle spent the month of September and a small portion of October in making a series of observations for latitude and azimuth at the trigonometric station Fitzsimmons, near the town of Baraboo, Wisconsin.

The small field observatory built at Minneapolis was taken apart and transported by rail and teams to Fitzsimmons, where it was again set up, and observations for latitude upon twenty-four pairs of stars were made with zenith telescope No. 5 between September 13 and 23. The azimuth of the line Fitzsimmons to Arlington was determined by observations upon Polaris with twenty-inch theodolite Coast and Geodetic Survey No. 113. Thirty series were observed in ten positions of the instrument.

Fitzsimmons and Arlington are stations in the triangulation of Wisconsin which is in charge of Acting Assistant John E. Davies, of Washburn University, Madison. College duties prevented Professor Davies from making other than occasional visits to Fitzsimmons while these observations were in progress, but all the resources of his party were cheerfully placed at Assistant Boutelle's disposal. Mr. George E. Brown, of Professor Davies' party, rendered constant and acceptable assistance both in observation and reduction during the entire duration of the work, while Professor Davies also took part personally on two nights.

The observations were completed during the first week in October, and Assistant Boutelle then returned to duty at the Office in Washington.

During the autumn and winter he revised and reduced the field observations in Minnesota and Wisconsin, turning into the Office twenty volumes of original and duplicate notes of observations and thirteen cahiers of reductions.

He continued also the correspondence with acting assistants involved in the immediate direction of State surveys with which he had been charged by direction of the Superintendent in August, 1886.

In June, 1888, he was instructed to take charge of the preparation and transportation to Cincinnati, and of the arrangement and exhibition there, of such instruments and apparatus of the survey as were available for the Exposition to be held in that city during the period from July 4 to October 27.

Surveys and examinations at Burnt Island, Michigan.—Under the heading "Special operations," which follows Section XVI in this volume, full mention is made of the special surveys and examinations at Burnt Island, Michigan, undertaken at the request of the Department of State and with the approval of the Secretary of the Treasury. These examinations were committed to the charge of Assistant C. H. Sinclair, under instructions, which took effect May 14, 1888. He completed the field-work June 6, and has since that date deposited in the archives the records and results of his surveys.

SECTION XV.

MISSOURI, KANSAS, IOWA, NEBRASKA, MINNESOTA, AND DAKOTA. (SKETCHES NOS. 1, 2, 14, 15, 17, AND 18.)

Continuation of geodetic operations preliminary to a triangulation of the State of Minnesota.—Reference was made in the last Annual Report to the progress of geodetic operations in the State of Minnesota, in response to a request from the authorities of the State to have the benefit of the appropriation for furnishing points for State surveys. Also to the appointment of Prof. W. R. Hoag, of the State University, as Acting Assistant, by the Secretary of the Treasury, upon the nomination of the Governor of Minnesota.

Early in June, Assistant C. O. Boutelle, under whose immediate supervision the State surveys had been placed, was instructed to take special charge of the work in Minnesota at its beginning. He was directed to search for and locate a base-line for future measurement, and also to furnish data for certain local surveys asked for by Professor Winchell, State Geologist. Professor Hoag was assigned to duty as Mr. Boutelle's assistant.

Field operations were begun in June, 1887, without delay, and continued throughout July and August. During this time a preliminary base was laid out and measured upon University avenue, in the northeastern part of Minneapolis, and a secondary triangulation was laid out and developed from it, which covered the cities of St. Paul and Minneapolis. Ten stations were occupied, and the geographical positions of forty-eight points determined. A final primary base-line of about five and a half miles in length was decided upon. It falls upon a public avenue in a portion of the outskirts of the city of St. Paul, and is included in the limits of the secondary triangulation already executed. The consent of the authorities of the city of St. Paul to the temporary use of the avenue for the measure of the base was obtained, and it will be measured as soon as an appropriation for the purpose becomes available.

The latitude of a point near the State University in Minneapolis was determined, and the position of the station referred to the dome of that building. Twenty-one pairs of stars were observed upon five nights with zenith telescope No. 5. Observations for azimuth of the preliminary base were made upon Polaris; thirty-three series being taken in eleven positions of twenty-inch theodolite No. 113. The longitude of the University had been determined by the Survey in 1873.

Owing to the extreme heat and drought that prevailed all summer, the reconnaissance could not be carried as far as was desirable, but the country was found to be favorable for triangulation at moderate cost with triangle sides of from fifteen to twenty miles in length. Further and more extended reconnaissance may show the practicability of longer lines.

Mr. Boutelle, in his report of the season's work, acknowledges the zealous and intelligent assistance given him by Acting Assistant Hoag.

Transcontinental line of geodetic leveling carried westward from New Haven, Missouri.—The extension westward of the line of transcontinental leveling from New Haven, Missouri, was committed to the charge of Subassistant J. E. McGrath by instructions issued April 2, 1888, with the understanding that Assistant Gershom Bradford and Subassistant Isaac Winston should report to him for duty in the party at an early date, and that as soon as they became well practiced in the methods of work the charge of it should be transferred to Mr. Bradford.

Field operations were begun April 17 by a careful determination of the instrumental constants of the geodesic micrometer levels Nos. 2 and 3. Two days later the line of levels was begun at a bench mark placed at New Haven, Missouri, by Assistant Andrew Braid in 1882. Mr. McGrath remained with the party until May 3, but gave up the charge of it to Mr. Bradford May 1.

Towards the end of May he inspected the field-work, and examined the records and computations, and having found the work progressing quite satisfactorily, he made a final transfer of it to Mr. Bradford, and made preparations to carry out instructions which assigned him to a term of service upon the Pacific coast.

Mr. Bradford, with the aid of Mr. Winston, continued the line of levels of precision to the end of the fiscal year. It had then reached a bench-mark between Osage City and Moreau Creek, a length of fifty miles having been completed, one observer running the forward line and one the backward line, except at the single river crossing encountered on the route.

The work followed the line of the Missouri Pacific Railway, and as permission to stop trains was refused by the railway authorities, the party was often compelled to walk long distances to and from the locality of work, and submit to many interruptions owing to the necessity of being at railway stations on time. During June the heat was exceedingly oppressive.

Occupation of stations for extending to the westward the transcontinental triangulation near the thirty-ninth parallel in Kansas.—At the beginning of the fiscal year, Assistant F. D. Granger, having finished a reconnaissance in which he had selected nineteen new stations for carrying his triangulation to the westward, was engaged in the occupation of station Bebè Mound, Douglas County, Kansas, one of the points in the transcontinental triangulation near the thirty-ninth parallel.

On the 5th of July, 1887, having completed work at Bebè Mound, he transferred his party to Eckman station, Leavenworth County. Both of these stations had been occupied in 1885, but no points beyond them to the westward had been selected.

The stations next in order were occupied as follows during the season:

On July 26 the occupation of Kanwaka, near Le Compton, was begun, and observations were made upon five primary, two secondary, and ten tertiary objects, the station being finished August 16. Kanwaka is in Douglas County, about ten miles northwest of the city of Lawrence, its name being that of the township in which it is situated. The observing tripod at this station was about fifty-seven feet above the ground.

On August 19 the party and instruments were transferred to station Simmons, which is situated upon a prominent hill in Marion Township, Douglas County. The observing tripod here was at a height of forty-five feet.

Mabon station, in Osage County, was next occupied. It is about six miles southwest of Carbondale, and four miles northeast of Burlingame, towns on the Atchison, Topeka and Santa Fé Railroad. The instrument was elevated on an observing tripod fifty-three feet in height. Five primary and seven tertiary objects were observed. Bad weather was encountered at this station, so that the work was delayed in completion.

After finishing the observations at Mabon, October 17, the party proceeded to Elevation, a station in Shawnee County about nine miles southwest of Topeka. This point is well known in Shawnee County. On its summit stands the Wesleyan Methodist Church and on its south face the Elevation school-house. The observing tripod, which is forty-five feet high, stands immediately north of the church. During the occupation of this station the weather was continuously favorable. Six primary and twenty-seven tertiary objects were observed, and work at the station was completed November 4. Among the tertiary points were the State House of Kansas, the State Insane Asylum, and several church spires in Topeka.

The last station occupied, Powell, is about three miles south of the town of Dover in Shawnee County. It is nearly in the center of the quadrilateral formed by lines from the stations Elevation, Mabon, Clark, and Adams. Four primary and fourteen tertiary objects were here observed, the instrument being mounted upon a tripod twenty feet above ground.

Field operations were closed at this station November 18, and after storing the instruments and camp equipage at Topeka and at Lawrence, Mr. Granger disbanded his party December 5.

He commends highly the services rendered by his only assistant in the work, Mr. A. P. Barnard.

During the winter, and until early in May, 1888, Mr. Granger was occupied in Office duty. Having been relieved from the Office and instructed to resume field-work, he arrived at Lawrence, Kansas, May 15, and was joined on the following day by Subassistant F. H. Parsons and Mr. T. O. Pulizzi, Recorder. Mr. A. P. Barnard, Foreman, having soon after reported for duty, the organization of the party was completed, and the erection of six observing tripod and scaffold signals was begun, these being needed in advance of the occupation of the stations.

While preparations were in progress for the occupation of station Adams, near Maple Hill, Wabaunsee County, Kansas, and about twenty-five miles west of Topeka, Mr. Granger put up a signal at the tertiary station Martin's Hill, near Topeka, and occupied that point to make measurements connecting the Kansas State House and other prominent objects in the city with the triangulation.

Heavy rains delayed the transfer of the party equipment to Adams station until June 26, and continued unfavorable weather prevented observations before the close of the month, but the station was put in readiness for geodetic and astronomical work.

For the fiscal year the statistics are:

Triangulation:

Area of, in square statute miles		960
Number of observing tripods and scaffolds built		7
Heights of observing tripods and scaffolds built, twenty to fifty feet.		
Number of stations occupied for horizontal measures	primary	6
	tertiary	2
Number of stations occupied for vertical measures		6
Number of geographical positions determined		22
Number of elevations determined trigonometrically		19

SECTION XVI.

NEVADA, UTAH, COLORADO, ARIZONA, AND NEW MEXICO. (SKETCHES NOS. 2, 15, 16, 17, AND 18.)

Determination by exchange of telegraphic signals for longitude of the line Salt Lake City–Walla Walla, forming part of the telegraphic circuit Salt Lake City–San Francisco–Portland–Walla Walla–Salt Lake City.—Reference was made under a heading in Section XI to the telegraphic longitude determinations between Portland, Oregon, and Walla Walla, Washington Territory, and between Walla Walla and Salt Lake City. And under a heading in Section X, to the determination of the line San Francisco–Portland by exchanges of telegraphic signals.

Assistants Edwin Smith and C. H. Sinclair, who took up towards the end of September, 1887, the exchanges of telegraphic longitude signals between the stations in Temple Block, Salt Lake City, and the station in the grounds of the Court-House at Walla Walla, completed their work October 22, having obtained exchanges of signals on six nights in each position of the observers. The preliminary computations show a satisfactory closing of the telegraphic circuit Salt Lake City–San Francisco–Portland–Walla Walla–Salt Lake City.

Occupation of stations for the extension eastward of the transcontinental triangulation near the thirty-ninth parallel in Utah.—At the beginning of the fiscal year, the party of Assistant William Eimbeck was established in camp upon the summit of Mount Nebo, in central Utah, and, as stated in the last Annual Report, had made good progress with the observations for horizontal directions. Mount Nebo, which has an elevation of twelve thousand feet above the sea-level, forms with Ibepah, Pilot Peak, and Ogden one of the great quadrilaterals by which the transcontinental triangulation in Nevada and Utah near the thirty-ninth parallel is advancing to the eastward.

During July, 1887, the observations at Mount Nebo were substantially completed; in addition to those for horizontal directions they included determinations of latitude, azimuth, and the magnetic elements. On the 2d of August, camp at Mount Nebo was struck and arrangements were begun for the transportation of the party, camp equipment, and instruments by wagons to a camp at the base of Mount Guyot, a distance of (approximately) ninety miles.

The greater part of the month was occupied in work preliminary to the occupation of the station. The mountain approaches were explored; about ten miles of trail were located and in part opened from the lower camp to the summit, signals were erected, heliotropers (twelve in number) were posted, camp established near the summit of the mountain, and the piers and the platforms for the instruments were prepared. On the 31st, the first observations for horizontal angles were made. These, with observations for vertical angles, and determinations of the magnetic elements, occupied the party during the month of September, and until October 3.

Camp was then struck, part of the force discharged, instruments no longer needed were sent to Salt Lake City for storage, and arrangements were made for the occupation of a station at Lake Shore Bench near Grantsville, Utah, and for the establishment of a tide-gauge and bench-mark at Hooper, near the shore of Great Salt Lake.

At Lake Shore Bench observations of horizontal and vertical angles and magnetic determinations were made. The corresponding "bench" near Hooper was referred by spirit-leveling to the water level of the lake. The astronomical station in Temple Block, Salt Lake City, was connected with the triangulation, and observations made near this station for the determination of the magnetic declination, dip, and intensity.

These operations, with those incidental to closing field-work for the season, occupied the time until the end of November, after which Mr. Eimbeck proceeded under instructions to Washington and reported for duty at the office.

Mr. J. H. Turner, Aid, rendered acceptable service during the greater part of the season, having joined the party June 8.

During the winter, and until towards the end of June, 1888, Mr. Eimbeck was occupied in completing the records and computations of his field-work. As soon as funds were available he was instructed to resume field operations in central Utah.

SPECIAL OPERATIONS.

Determinations of gravity on the Hawaiian Islands, at San Francisco, on Mount Hamilton, and at Washington, District of Columbia.—The special assignment of Subassistant E. D. Preston to duty on the Hawaiian Islands, made at the request of the Hawaiian Government and approved by the Treasury Department, was still in effect at the beginning of the fiscal year.

On July 1, 1887, Mr. Preston was making the ascent of Haleakala, a well-known volcanic mountain on the island of Maui. Observations for gravity had been completed at the base station, Haiku, on the evening of June 29, and the ascent was begun the next day, the entire caravan numbering eighteen men and twenty-five animals. After resting one night at Olinda, which is at an elevation of four thousand feet, and which lies at the lower limit of the cloud region, the party made an early start next morning, and after two miles of travel reached a point beyond which wagon transportation was impracticable. The larger instruments, the tents, and provisions having then been packed on muleback, and the chronometers, barometers, and thermometers taken by hand, the ascent of the last five thousand feet was begun. This occupied five hours, and at three in the afternoon the party reached the edge of the crater. After a halt for an hour to allow the animals to recover somewhat from the effects of the rarity of the atmosphere and the travel over rough lava, the party advanced three miles farther to Comotierra, a point just below and to the south of the triangulation station Pakaoao, which has an elevation of about ten thousand feet above sea level. Here, within fifty feet of the perpendicular walls of the extinct crater of Haleakala, which is half a mile deep and twenty miles in circumference, a pendulum house was prepared in an open space between two large rocks which afforded the requisite stability. This space was inclosed partly by stone walls and partly by blankets and tarpaulins, and a fairly constant temperature was thus maintained, notwithstanding the large range in the open air, ice being formed nearly every night.

At Pakaoao full sets of determinations of gravity were obtained during eleven days with each of the two pendulums, the yard pendulum, which was used in the determinations of 1883, and the meter pendulum. The swings were made day and night without interruption. Time and latitude were determined with a meridian telescope. For latitude twenty-five pairs of stars were observed.

As the observations were made at a station several thousand feet above the usual limit of the cloud belt, the weather was generally favorable and the atmosphere extremely clear, many stars being observed before sundown with a telescope of two and a half inches aperture and magnifying power of seventy.

Prof. W. D. Alexander, Surveyor-General of the Hawaiian Islands, accompanied the expedition to the summit, and remained a number of days. Mr. Preston acknowledges the aid derived from his experience and good judgment.

Remarkable variations in the magnetic declination were noticed. All lava found on one of the peaks is highly magnetic, and changes of declination of several degrees in a distance of two miles were found to occur on the floor of the crater.

After completing the observations at Pakaoao, Hana and Ka Lae o Ka Ilio in the district of Kaupo were occupied as latitude stations between July 20 and August 2. Both these are at the level of the sea. At the latter place as many as seventy-five pairs of stars were observed on a single night, an average of ten pairs per hour being taken.

From August 7 to August 30, Mr. Preston was at Honolulu, engaged in office work. On the latter date his connection with the Hawaiian Government ceased, and he sailed for San Francisco. Reference is made under headings in Sections X and III to comparative determinations of gravity made by him in California and at Washington, District of Columbia.

During his stay in the Hawaiian Islands, from January 12 to August 30, 1887, he occupied fourteen latitude stations, three of which were gravity stations also. The latitude stations were generally chosen at places best adapted to bring out the deflections of the vertical, being established at points to the north and south of the high mountains. The pendulum was swung at a great elevation, at the sea level, and at a station occupied in 1883 by the United States Eclipse Expedition. This was done with a view of studying the downward attraction of the mountain, of throwing light on its internal constitution, and for determining the ratio existing between its mean density and that of the earth.

For latitude, the whole number of observations was nearly fifteen hundred, being on the average more than one hundred to each station. Preliminary reductions seem to indicate a difference of nearly forty seconds of arc between the astronomical and geodetic latitudes in Oahu, and as much as fifty-eight seconds at Kaupo on Maui, while Pakaoao falls half-way between Haiku and Kaupo. At Kohala on Hawaii there is a deflection of half a minute toward the south, while at Hilo, sixty miles distant, the plumb line is deflected in the opposite direction nearly half the amount. On top of Haleakala the diminution of the force of gravity is not as great as was supposed; that is, the downward attraction of the mountain is greater than has been found generally on great elevations. The pendulum experiments show that the mean density for the whole mountain mass is quite equal to that of its surface density, and that the mountain is not hollow, as has been claimed for most continental elevations, notably those of India. Using a density derived from pendulum observations, and considering the mountain as a paraboloid of revolution, an approximate value of its attraction at Kaupo has been calculated. Applying this attraction brings the astronomical latitude to agree with the geodetic one, as carried around the island from the northern station at Haiku.

At the meeting of the American Association for the Advancement of Science held at Cleveland, Ohio, in August, 1888, Mr. Preston, with the authority of the Superintendent, read a paper he had prepared on the Deflection of the Plumb-line and Variations of Gravity in the Hawaiian Islands. This paper was subsequently published in the American Journal of Science for November, 1888. The general conclusions which he draws from his discussion of the Hawaiian observations he states as follows:

I. Deflections of the plumb line are greater on island than on continental mountains, presumably on account of the lighter surrounding sea-water; and gravity is not in defect, because it is here estimated from the true sea level, and not from a sea level by continental attraction.

II. Deflections appear to be greater in the vicinity of extinct volcanoes than near active ones.

III. The so-called "hidden causes" which, in the case of the Himalayas, give a variation of gravity several times as great as those arising from the attraction of the mountains themselves, do not exist in the Hawaiian Islands.

Mr. Preston acknowledges the uniform kindness shown him, both by the members of the Government Survey and by the residents in different parts of the kingdom. In the pendulum observations he had the aid of Messrs. F. S. Dodge and W. A. Wall, of the Hawaiian survey. All of the latitude and time observations were made by himself. The stations were selected by Professor Alexander.

The following table presents the statistics of the latitude work:

Latitude work, Hawaiian Islands, 1887.

Station	Number of pairs observed on each night.							Totals.
Puuloa	30	38	31	....	....	....	....	99
Kahuku	22	33	40	21	....	....	....	116
Waimea	17	10	27	10	34	27	3	128
Koloa	8	13	28	26	16	23	....	114
Hanalei	20	17	25	31	19	18	...	130
Honolulu	29	32	35	28	..	...	....	124
Kohala	33	31	32	....	....	....	....	96
Hilo	9	33	8	5	5	16	6	82
Ka Lae	19	31	20	22	35	...	...	127
Kailua	15	8	12	25	..	....	..	60
Haiku	30	19	17	9	16	....	...	91
Pakaoao	18	23	9	20	18	....	....	88
Hana	7	20	12	11	31	..	....	81
Kaupo	2	24	75	9	20	25	..	155
Total number of determinations								1,491
Average number for one station								106

Special surveys and examinations, made at the request of the Department of State and with the approval of the Secretary of the Treasury, at Burnt Island, Michigan.—A question having arisen between the United States and the Dominion of Canada as to the exact location of a fishing net belonging to S. F. Tolsma, a citizen of the United States, which had been seized by the Canadian authorities, because, as they alleged, it had been spread in Canadian waters, the Secretary of State made request of the Secretary of the Treasury in March, 1888, that the location, direction, and length of the net at the time of seizure should be ascertained as nearly as practicable by a survey to be made by a competent officer of the Coast and Geodetic Survey.

Instructions were accordingly issued by the Superintendent to Assistant C. H. Sinclair, directing him to proceed, as early in the spring as the condition of the ice would permit, to Burnt Island, in Lake Huron, the locality of the seizure, and to locate and determine carefully, with reference to adjacent shore-lines, the boundary between the United States and Canada in that vicinity, this location and determination of the boundary to be in exact conformity with the tracing of the Boundary Treaty Map furnished to this Office by the Department of State; also to ascertain, with reference to this boundary line, the position of the Tolsma net.

Permission having been obtained from the Canadian authorities for the establishment on Canadian ground of such stations as would be needed to be occupied in triangulation, Mr. Sinclair, soon after his arrival, May 22, having selected these stations, with others on the American side, determined the points required for a topographical survey of the shore-line of Burnt Island and other islands in the vicinity, and determined in position, with reference to the boundary line, the buoys that had been set to mark the position of the Tolsma fishing net.

His report, dated June 29, 1888, points out certain errors in the survey made by an officer of the Royal Navy before the breaking up of the ice in that year, and shows conclusively that the Tolsma net, when seized, was entirely within American waters. But one question was left open to be decided by subsequent measurements, that of the length of the net, the Canadian authorities claiming for it a length much beyond the maximum length of the nets that came under Mr. Sinclair's examination.

The results of his survey, which are shown on three tracings accompanying his report, were transmitted by the Superintendent to the Secretary of the Treasury under date of August 1; also a supplemental report with suggestions as to the advisability of marking the boundary in the locality of the fishing areas under survey, and a recommendation that in order to give such marking an authoritative character both Governments should take part in it.

Towards the end of August a letter was received from the Treasury Department inclosing a communication from the Secretary of State, transmitting to the Superintendent the thanks of that Department for the valuable report made by this Office.

COAST AND GEODETIC SURVEY OFFICE.

The annual report of Office operations (Appendix No. 4) is submitted by Mr. B. A. Colonna, Assistant in Charge of Office and Topography. With it appear the reports for the fiscal year of the chiefs of the several Office Divisions. These indicate throughout a steady performance of duty, and a desire for the advancement of work by improved adaptations of means to ends, and by the introduction of better methods and processes whenever practicable.

Assistant Charles A. Schott continues as heretofore in charge of the Computing Division. Mr. Schott alludes to the large amount of field-work which needs speedy reduction and discussion, and to the necessity for the employment of two additional computers, one for magnetic, the other for geodetic reductions. By the resignation of Mr. Alexander Ziwet, which took effect September 23, 1887, the Division lost the services of a very able computer, thoroughly acquainted with the methods of calculation, and possessing also that general knowledge which added to the value of his work.

Besides attending to correspondence referred to him from the Office, and directing the labors of the computers, Mr. Schott devoted much of his time to the preparation of special reports. Those which are intended for publication are referred to under the heading Special Scientific Work in Part I ot this volume.

In the Drawing Division, under the charge of Assistant E. Hergesheimer, special effort was made to place the results of recent surveys promptly before the public, and with the co-operation of the Engraving Division and by the aid of photolithography, charts of the resurveys in Delaware Bay and New York Harbor and approaches were prepared in a less time after the close of field-work than had ever before been accomplished by the Office. Charts reproduced on full scale from the original sheets by photolithography have been received with much favor by the public. For local purposes such charts are of great value.

At the request of the Attorney-General of the United States, and for use in determining the title of the Government to the Potomac Flats, there were prepared for publication careful tracings of the Dermott Map (1798) and of the King Plats (1803) of the City of Washington.

During some unavoidable absences of Mr. Hergesheimer, Mr. A. Lindenkohl, Chief Draughtsman, directed satisfactorily the work of the Division. A tabular statement appended to the report shows what charts were completed or in progress during the year.

The annual report of the Engraving Division is submitted by Assistant Herbert G. Ogden, under whose administration its high standard of efficiency has been maintained. With the charge of the Engraving Division is associated the charge of operations in the Electrotype and Photograph rooms and in the Plate Printing office.

All of the engravers were at times employed in making the miscellaneous corrections to plates and additions on them that are required to keep up to date Aids to Navigation, and the results of hydrographic examinations, resurveys, etc. This class of work is always one of great urgency, in order that the supply of corrected charts may be maintained for the use of the public. There were in hand for correction in these particulars during the year five hundred and fifty-seven plates.

A number of engraved plates of important charts were completed. Among them may be mentioned the Delaware Entrance from resurveys; Cape Fear River, showing recent improvements by the United States Engineers; the Columbia River to Portland, and a general chart of the Pacific coast from Point Arena to Cape Mendocino. Tabular statements of engraved plates begun and finished during the year accompany Mr. Ogden's report. He refers to the receipt at the Office on April 21, 1888, of a copper-plate engraving of the City of Washington, believed to be a copy of the Boston plate. The original Boston plate is yet to be recovered.

In order to obtain for the records of the Division a catalogue of engraved plates arranged in a geographical sequence so as to give a concise abstract of the work representing a particular locality, Mr. Ogden began the preparation of such a catalogue, placing the work in the hands of Assistant Edwin Smith, who was assigned to duty for this purpose, and who had completed a rough draught of the catalogue at the date of being ordered to field duty in April, 1888.

Mr. D. C. Chapman carried on most satisfactorily the operations of the Electrotyping and Photographing Division under Mr. Ogden's general direction, and has submitted at his request a statement of the results of various experiments made and improvements introduced by him into the apparatus employed. The system of mounting photographic prints to scale was continued in successful operation, and at the request of the Secretary of the Smithsonian Institution an exhibit of the method was prepared for the Cincinnati Exposition. A machine for filing the backs of electrotype plates, intended to save the labor and delay of filing the plates apart by hand, which was devised by Mr. Chapman and put up during the year, has worked well, furnishing a smooth even surface at a much reduced expenditure of time and labor.

The Plate-Printing office was as heretofore in immediate charge of Mr. F. Moore, Foreman. Mr. Ogden observes that this class of work is laborious and exacting, and it is therefore gratifying to find that the number of impressions supplied to the Chart Room, thirty-two thousand three hundred and forty-five is larger than for any preceding year.

Mr. John H. Smoot continued as heretofore to perform the clerical work of the Division; great credit is due him for the care and precision with which this is done.

In December, 1887, the Chart Division was organized, and Assistant W. H. Dennis was instructed to take charge of it, his special duty being to have the custody of the charts and to direct their correction and issue. He reports that the total number of charts disposed of during the year was forty-four thousand five hundred and ninety-five, which was an increase of nearly thirty per cent. over the issue of the year before. Of this number twenty-five thousand two hundred and seventy-three were sent to agents for sale; eleven thousand six hundred and eight issued to meet demands from the Executive Departments, and two thousand four hundred and eighty-three in response to requests from members of Congress.

Mr. Dennis calls attention to the fact that during the last six months of the year upwards of three thousand one hundred corrected charts were sent to the Hydrographic Office of the Navy, where, notwithstanding the very critical examination to which they are subjected, not a single error was found for which the Chart Division was responsible.

This he attributes to the painstaking care of Messrs. Barker and Upperman, who had immediate charge of making the corrections. Mr. H. G. Eicholtz was continued in general charge of the Chart Room. Lists of new charts added to the Catalogue and tabular statements of charts on hand, received and issued during the year, accompany Mr. Dennis' report.

The report submitted by Assistant Andrew Braid of the operations of the Instrument Division indicates a high state of efficiency in that important department of the Office. Mr. Braid's efforts to place in thorough repair the means and appliances for making instruments were ably seconded by Mr. E. G. Fischer, Chief Mechanician, and Mr. O. H. French, Chief Carpenter and Model Maker. All of the instruments needed on the Survey are now made in the shop. Among those constructed during the year were two astronomical transits for the use of the longitude parties from general outlines submitted by Assistant Edwin Smith, and two geodesic levels from plans submitted by Mr. Braid. Working drawings and patterns are being made for six new eight-inch repeating theodolites, three of which will be adapted for latitude and azimuth work.

Due attention was given to the miscellaneous duties of the Division, which include the care of the instruments, camp equipage, and general property. Mr. R. C. Glascock served as Property Clerk during the year.

The work done in the Tidal Division during the year is reported by its chief, Mr. A. S. Christie. Mr. L. P. Shidy has continued on duty as his principal assistant. Tide-tables for all the principal ports on the Atlantic and Pacific coasts were prepared and published a year in advance. The latest data have been brought into requisition to improve the results for times and heights of high and low water, and the predictions have been extended to some new points.

In addition to the current work, which was kept up promptly to date, a number of special investigations were undertaken by Mr. Christie. Among them were the following: A careful determination of mean half-tide level at Sandy Hook; an investigation of the corrected establishments and ranges at San Francisco, California, and at Astoria, Oregon; an investigation of the West Florida, Cat Island and Biloxi, and Puget Sound tides, and a verification of the report made by Prof. G. H. Darwin in 1883 on the Harmonic Analysis of the Tides, followed by the preparation of certain fundamental tables intended to introduce greater accuracy into the tidal reductions and predictions of the Survey.

Mr. M. W. Wines has continued in charge of the Miscellaneous Division. In December, 1887, he was relieved from the duties and responsibilities connected with the custody and issue of charts by the organization of the Chart Division, and the assignment of Assistant Dennis as its chief. The work of the Miscellaneous Division now includes the correspondence with sale agents relating to the publication of the Survey, the care of the accounts connected therewith; the custody and issue of stationery; the care of the annual reports when received from the Public Printer, and of the correspondence between the Office and the Printer; the purchase of miscellaneous Office supplies and the supervision of the Office buildings.

Tabular statements of the receipt and issue of publications accompany Mr. Wines' report. Mr. Freeman R. Green continued to serve very acceptably as clerk to the Division.

The annual report of the Archives and Library is submitted by Mr. Artemas Martin, who has remained in charge of the receipt and registry of the original and duplicate records, of the computations, and of the original topographic and hydrographic sheets, and has had also the care of the Library. With the report are tables showing the number of the several classes of records and computations received and registered. Note is made of such topographic and hydrographic sheets as were accompanied by descriptive reports.

A card catalogue of the Library, which has been for some time in progress, is now nearly finished.

The complicated and laborious operations of the Accounting Division are fully described in the annual report presented by Mr. John W. Parsons, who has remained in charge of it, and whose unremitting efforts to increase its efficiency both by personal labor and by the introduction of improvements in its organization, deserve special recognition. The disbursements for the Survey continue to be made by, and the responsibility for them still rests with, Mr. George A. Bartlett, Disbursing Clerk of the Treasury Department, who has hitherto performed this service without additional compensation.

In order to verify readily the financial condition of the Survey, and obtain a check against errors, there was established at the beginning of the fiscal year a system of semi-monthly trial balances and monthly balance-sheets showing the receipt and expenditures under the appropriations. This system was found by trial to be very satisfactory, and its results were approved upon examination by a special committee from the office of the First Comptroller of the Treasury.

Messrs. Eugene B. Mills, Accountant, and W. H. Lanman, General Bookkeeper; Mrs. S. M. Taliaferro, Book-keeper and Entry Clerk, and Miss Paula E. Smith, General Clerk, rendered very satisfactory service.

In view of the facts that the work of the Accounting Division is constantly increasing in volume and that much time is necessarily lost by the present arrangements for making disbursements, Mr. Parsons, in concluding his report, again urges the need of the Survey having its own Disbursing Officer.

Early in October, 1887, Assistant O. H. Tittmann was instructed to take charge of the Bureau of Weights and Measures. In virtue of this assignment, he was directed to prepare for publication the manuscript of a report on the construction and distribution of Standards of Weight and Measure, which had been compiled chiefly by the late Assistant H. W. Blair, but which had not received the final revision of Professor Hilgard, then Superintendent. Before the report could be properly prepared for the Printer, Mr. Tittmann found it necessary to index the records of the Weights and Measures Office. These records had been accumulating since 1844. The work was done with care and good judgment by Subassistant F. H. Parsons, under Mr. Tittmann's direction. Assistant J. B. Weir was attached to the Division during part of the fiscal year. He assisted in the comparisons of standards and in making and revising computations.

The long experience and knowledge of details of Dr. J. J Clark, Adjuster, was of great service in the work of the year; he made all the weighings, assisted in the comparisons of standards, and prepared the Weights and Measures Exhibit for the Cincinnati Exposition.

For the results of the experimental researches and the comparisons of standards of length and capacity instituted by Mr. Tittmann reference must be made to his report. He urges the great need of having a comparing room so constructed that its temperature can be controlled artificially, so that at any time during the year comparisons of standards of length can be made at any temperature desired.

An abstract of information furnished by the Division is appended to the report.

In the Office Division, under the immediate direction of the assistant in charge, Dr. W. B. French continued to render very efficient and satisfactory service as executive clerk.

In the Office correspondence, and in the preparation of the monthly reports, Miss S. C. Ayres served very acceptably during the year, and during part of the year Miss F. Cadel. Miss S. B. Harvie, a skillful type-writer, was transferred to the Treasury Department January 1. Miss K. Lawn served satisfactorily as type-writer during the year, and Miss C. Turnbull since March 1, as copyist.

Mr. W. B. Chilton continued to serve as clerk to the Superintendent, and has made a report stating the details of his clerical duties.

SUB-OFFICES U. S. COAST AND GEODETIC SURVEY.

Sub-office at Philadelphia.—Assistant S. C. McCorkle, who has remained in charge of the Sub-office at Philadelphia, reports that information has been applied for by and furnished to various persons and organizations, among whom he mentions Messrs. Henry Winsor & Co., Mr. John McArthur, jr., Architect of the new City Hall, Prof. L. M. Haupt, of the University of Pennsylvania, the Bureau of Surveys, the Board of Trade, Board of Port Wardens, and the Harbor Commission of the Port of Philadelphia; the different branches of the Government service located in the city, and the American Archæological Society of Cambridge, Massachusetts.

The facilities of the Sub-office were extended to the U. S. Advisory Board of the Harbor Commission, of which Assistant Henry Mitchell and Henry L. Marindin were members. Six sessions of the Board were held at the Sub-office in 1887 and 1888, Mr. Marindin acting as Secretary. He was also on duty in the Office at various times throughout the year. The records of the Board are in charge of Mr. McCorkle.

Assistant R. Meade Bache was on duty in the Sub-office during the greater part of the year. He made pantographic reductions of eleven original sheets of the surveys of the Delaware and Schuylkill Rivers from scales of 1-2400, 1-4800, and 1-5000 to one uniform scale of 1-9600, and made projections on this scale for prospective work on those rivers. He made tracings of maps north of Philadelphia belonging to the City Engineer Office, and reproduced two old topographical sheets of the vicinity of Boston, Massachusetts.

Assistant Charles M. Bache was on duty in the Sub-office at various times.

Assistant McCorkle has submitted a full report of his observations of the ice movement in Delaware River and Bay during the winter of 1887-1888. An abstract of this report is given under a heading in Section II.

Sub-office at San Francisco.—In addition to the various duties involved in his assignment to the general charge of the land operations upon the Pacific coast, Assistant George Davidson had charge of the Sub-office at San Francisco. He has attended to the official correspondence and answered all calls for information.

He has prepared special reports upon the Fisheries of Alaska, and the location for a quarantine station at San Francisco. A public meeting having been called by the Mayor of the city to consider the location for this station, at which were present members of the State and City Boards of Health, the Supervisors, Surgeons of the Marine Hospital Service, and other prominent citizens, Mr. Davidson appeared and presented a chart of the bay upon which he had plotted the several sites suggested, taking occasion also to review their respective advantages or disadvantages.

Subassistant Fremont Morse, while on duty under Mr. Davidson's direction at the Sub-office, made a minute inventory of all the Office property, including instruments and camp equipage. The store-room for this property is in charge of Mr. Vincente Denis, who, in addition to other duties, has faithfully attended to it for years.

Mr. Morse prepared for the Archives the records and results of the field-work at Macho station, made a reduction of the transit observations at Balch station of 1886, inked and traced the topographical sheets of Suisun Bay, and made descriptive reports of two of these sheets. He was occupied also upon the work of the latitude and time observations at Lafayette Park station, and gave assistance in the preparation of the base bars for the field.

This work, having been performed at the Sub-office, is here noticed in some detail.

PREPARATION OF BASE BARS FOR THE LOS ANGELES BASE.

In connection with the main triangulation, Mr. Davidson made a thorough overhauling of the base bars used in the measurement of the Yolo base, in anticipation of their early use on the Los Angeles base. This work he did personally, as far as practicable, with the aid of Messrs. Lawson and Morse, and the mechanician's work was done under direct supervision. All of the Borda scales were examined and the accidental imperfections corrected. The indexes on two base bars, which had become almost obliterated by their use on the Yolo base, were recovered and marked anew in their identical places. The standard was found to be injuriously affected by galvanic action between the steel and zinc bars and brass supports, but was cleaned and the Borda scales corrected. The ends of all the bars were in good condition, care having been taken to clean them systematically for the last seven years.

In order to guard against rapid changes of temperature in the measuring bars, Mr. Davidson had all the wooden beams covered with two thicknesses of sluice blanketing, three-quarter-inch thick boiler felt, and then by canvas.

This done he had them removed for comparison tests to the pendulum house at Lafeyette Park station. Around this house he had been authorized to have a wooden shell placed, so that it is now double walled and roofed, the space between the inner and outer building being about eight inches. The inside is lined with heavy paper, and the changes in temperature were found to be small.

For the base bars and the comparators, four brick and cement piers were built, and Messrs. Lawson and Morse were instructed to begin a series of comparisons in order to familiarize them with the work and detect any error of the working parts. To the index or contact slide ends of the two bars, Mr. Davidson had had magnifiers adjusted; these are of great assistance in setting the slides at zero. The apparatus was thus made ready for crucial comparisons.

In response to a request from the Superintendent for an opinion upon the proper form of base-bars for the measurement of geodetic bases of the highest character, Mr. Davidson furnished a report and rough diagrams in explanation. The principal point to be decided, is, in his judgment, in the use of a compound bar, or a single steel bar of proper section, and with such coverings as will prevent any rapid change of temperature when employed in the field. The connection of the thermometer should be by insertion of its bulb in mercury that is in contact with the bar itself. He expresses himself as satisfied the more he has thought on the subject, and the more experience he has gained with protected bars and beams, that the single well-protected steel bar is the best form, and that thermometers, connected with the bar as he recommends, will exhibit its temperature with reasonably close precision.

Instruments.—The Assistant in Charge of the Office having submitted to Mr. Davidson for criticism the plans for a theodolite proposed for use on the Survey, he made a report thereon.

COAST PILOT WORK.

In October, 1887, Mr. Davidson transmitted to the Office the manuscript of the fourth edition of the Coast Pilot of California, Oregon, and Washington Territory. Since that time he has accumulated much material that will be added in the proof-reading, and obtained the latest data relating to changes in lights, buoys, etc.

He began the reduction of the views which he had made of headlands, points, islands, and rocks during the last twenty years. Mr. Westdahl, under his direction, undertook several special trips on the coast steamers and on the Light-House vessel to obtain views. Some photographs had also been secured. The whole number of views is about four hundred, of which between three hundred and three hundred and fifty are being reduced for the Coast Pilot. Assistant Cleveland Rockwell was assigned to the special duty of preparing these views on bristol board, and reported May 7, 1888. He has given more than his regular office time to the work of reproducing them, and has imparted his artistic touches to the sketches.

In March, 1888, under authority granted by the Secretary of the Treasury, Captain Shepherd, of the revenue-cutter *Rush*, conveyed Mr. Davidson down the coast as far as Piedras Blancas, in order that he might get additional views and photographs for the Coast Pilot, and more particularly of the notable land-fall the "Twins," which are five thousand feet above the sea-level, and only three miles from the shore.

AIDS TO NAVIGATION.

Recommendations with regard to aids to navigation were made as follows, by Mr. Davidson: The placing of a light-house and fog-signal on the west end of Patos Island, and the same on the west end of Stuart Inlet in the Canal de Haro; the adoption of a fog-signal ship off the Bay of the Columbia River; of a light-house and fog-signal on Richardson's Rock off San Miguel Island, and of buoys off Point Buchon, and in the Cape Mendocino Passage, and in various other places.

At the request of the Superintendent, he wrote a description of the three positions available for a light-house at Point San Louis Obispo.

FIELD CATALOGUE OF STARS.

During the year, outside of official hours, he was engaged in adding azimuth stars to the second edition of the Field Catalogue of stars.

EARLY EXPLORATIONS.

He nearly completed also, outside of official hours, an exhaustive examination to identify Sir Francis Drake's landing in California in 1579. This research led him to gather many interesting charts relating to the subject, and especially those of Dudley, based upon the personal draughts of Drake, Cavendish, and others. He obtained also the first photographs of the original charts from which Dudley compiled those that appear in the *Arcano del Mare*, and upon these he found original magnetic variations by Drake, Cavendish, and others, and from latitude 40° to Cape Corrientes. Even the local disturbance near Playa Maria Bay, in southern California, established by Kellett and the latest observations of this year, is found in these charts.

Mr. Davidson furnishes a list of the records, computations, and original sheets, topographic and hydrographic, with tracings, forwarded by him to the Office during the year.

He acknowledges assistance received from Mr. Charles B. Hill in Sub-office work until his resignation, and subsequently by Mr. Frank W. Edmonds.

He commends Mr. Ferdinand Westdahl for his services as draughtsman, and for his willingness and promptness to attend to any matters that come up unexpectedly.

CONCLUSION.

Assistant Edward Goodfellow has been continued in charge of the preparation and editing for publication of the Annual Reports, and the Appendices thereto. He had also charge of the editing of the Bulletins of the Survey.

The printing of the Report for the fiscal year ended June 30, 1886, was completed, and the edition ordered by Congress was received at the Office in July, 1888.

Throughout the past year, ready co-operation has been afforded by other Departments and Bureaus of the Government in the work committed to this Survey whenever such co-operation has been asked, and cordial acknowledgment has been made of the value of the services rendered by its officers to other Departments and Bureaus in response to official requests.

I have specially to acknowledge the support of the Secretary of the Treasury in giving his entire sanction to the transmission to Congress of increased estimates for the field-work, and in thus recognizing the fact, so often urged heretofore, that adequate appropriations for a work of this character yield larger results at a less comparative cost, and are therefore in the interest of a wise economy.

Respectfully submitted.

F. M. THORN.
Superintendent.

Hon. C. S. FAIRCHILD,
Secretary of the Treasury.

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PART III.

APPENDICES.

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APPENDIX No. 1.—1888.

DISTRIBUTION OF THE PARTIES OF THE COAST AND GEODETIC SURVEY UPON THE ATLANTIC, GULF OF MEXICO, AND PACIFIC COASTS, AND IN THE INTERIOR OF THE UNITED STATES DURING THE FISCAL YEAR ENDING JUNE 30, 1888.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION I.				
Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island, including coast and sea-ports, bays and rivers.	No. 1	Triangulation	C. H. Boyd, assistant; R. H. Bayard.	Triangulation of Cobscook Bay, Maine, and of the St. Croix River, from the primary triangulation near its mouth towards the Initial Monument of the Northeastern Boundary at its source.
	2	Topography	C. M. Bache, assistant	St. Croix River, between Pleasant Point and Shortlands Station.
	3	Hydrography.....	Lieut. F. H. Crosby, U. S. N., assistant; Ensigns A. W. Dodd, N. J. L. T. Halpine, R. O. Bitler, W. B. Fletcher, M. Johnston, and Jos. Strauss, U. S. N.	Hydrographic survey of St. Croix River completed, and hydrography of Cobscook Bay begun. (See also Section VIII.)
	4	Triangulation ...	O. H. Tittmann, assistant	Triangulation for the determination of light-houses and other points between Grand Manan Island and the coast of Maine.
	5	Topographical inspection.	Charles Hosmer, assistant	Inspection of topographical work upon the coast of Maine.
	6	Topography	Eugene Ellicott, assistant	Topographical survey of Cobscook Bay, Maine.
	7	Topography	J. H. Gray, aid	Topographical survey of the south and north branches of Cobscook Bay, Maine. (See also Section VI.)
	8	Hydrographic examinations.	Lieut. G. H. Peters, U. S. N., assistant; Ensign W. J. Maxwell, U. S. N., John Ross, compiler.	Hydrographic examinations on the coast of Maine for the Atlantic Coast Pilot.
	9	Tidal observations	J. G. Spaulding, tidal observer	Completion of the record of tidal observations at the automatic tidal station at Pulpit Cove, North Haven Island, Penobscot Bay, Maine. (See also Section II.)
	10	Magnetic observations.	James B. Baylor, assistant........	Magnetic observations at stations in Maine and Massachusetts. (See also Section III.)
	11	Special triangulation.	Henry L. Whiting, assistant; Gershom Bradford, assistant; C. H. Van Orden, assistant.	Determination of the boundary lines of towns in the State of Massachusetts.
	12	Physical hydrography.	Henry L. Marindin, assistant; E. E. Haskell, Homer P. Ritter.	Coast of Cape Cod peninsula. (See also Section II.)
	13	Triangulation and topography.	Henry L. Whiting, assistant; W. I. Vinal, assistant; R. A. Marr, subassistant; E. L. Taney, subassistant.	Triangulation of Nantucket and Vineyard Sounds, and topographical resurveys on Nantucket and Martha's Vineyard.
	14	Triangulation	R. A. Marr, subassistant	Triangulation of Nantucket and Vineyard Sounds. (See also Sections III and XI.)
	15	Topography	E. L. Taney, subassistant	Topographical resurvey of the shore-lines of Nantucket, Muskeget, Tuckernuck, and the small islands in their vicinity. (See also Section VIII.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION I.—Continued.	No. 16	Topography	W. Irving Vinal, assistant	Topographical resurveys of the shore-lines of Vineyard Sound, Massachusetts.
	17	Off-shore hydrography.	Lieut. J. E. Pillsbury, U. S. N., assistant.	Off-shore soundings between Montauk Point and Phelps Bank. (See also Sections II, V, and VI.)
	18	Hydrography	Lieut. C. P. Perkins, U. S. N., assistant; Ensigns H. W. Harrison, N. J. L. T. Halpine, Baine C. Dent, and Franklin Swift, U. S. N.	Hydrographic resurveys in Vineyard Sound and in the channels and harbors adjacent.
	19	Hydrography	Lieut. J. F. Moser, U. S. N., assistant; Lieut. E. E. Wright, U. S. N.; Ensigns H. A. Field, W. O. Hulme, H. P. Jones, and H. E. Parmenter, U. S. N.	Off-shore and in-shore hydrography of the approaches to the western end of Vineyard Sound, to Buzzard's and Narragansett Bays, and to the eastern end of Long Island Sound. (See *also* Section VI.)
	20	Hydrography	Lieut. S. C. Paine, U. S. N., assistant.	Hydrographic resurveys in Vineyard and Nantucket Sounds. (See also Section II.)
	21	Hydrographic examinations.	Lieut. G. H. Peters, U. S. N., assistant; John Ross, compiler.	Hydrographic examinations for the Coast Pilot on the southern coast of Massachusetts, including Nantucket and Vineyard Sounds and Buzzard's Bay.
SECTION II. Connecticut, New York, New Jersey, Pennsylvania, and Delaware, including coast, bays, and rivers.	No. 1	Hydrographic examination.	Lieut. S. C. Paine, U. S. N., assistant.	Hydrographic examination in Stonington Harbor, Connecticut. (See also Section I.)
	2	Current observations.	Lieut. J. E. Pillsbury, U. S. N., assistant.	Examination of coast currents in the approaches to New York Harbor. (See also Sections I, V, and VI.)
	3	Triangulation	A. T. Mosman, assistant	Triangulation of the south shore of Long Island from Montauk Point westward. (See also Sections XIII and XIV.)
	4	Topography	C. T. Iardella, assistant	Resurvey of shore-line on Long Island from Hog Neck to Riverhead, and of the ocean shore from Amagansett westward.
	5	Topographic resurveys and hydrographic examinations.	W. H. Dennis, assistant	Shore-line resurvey, south coast of Long Island from Babylon to the westward. Soundings on bar at Fire Island Inlet.
	6	Physical hydrography.	Henry Mitchell, assistant	Physical hydrography of New York Bay and Harbor. The under-run of the Hudson River; its relation to New York Bar.
	7	Physical hydrography.	Henry L. Marindin, assistant; E. E. Haskell, Homer P. Ritter.	Continuation of physical hydrographic surveys in New York Bay and Harbor. (See also Section I.)
	8	Geodetic leveling.	J. E. McGrath, subassistant; John Nelson, aid; F. A. Young, recorder.	Geodetic leveling for the connection of the tide-gauges and bench-marks in New York Bay and Harbor and vicinity. (See also Sections VIII, XIV, and XV.)
	9	Tidal observations.	A. J. Brennan, J. G. Spaulding, observers.	Continuation of tidal record from automatic tide-gauge at Sandy Hook.
	10	Geodetic operations.	Prof. L. H. Barnard, acting assistant; Joseph Hergesheimer, assistant.	Reconnaissance for connecting the triangulation in the southern part of the State of Pennsylvania with the primary triangulation in Maryland. (See also Section VI.)
	11	Physical hydrography.	S. C. McCorkle, assistant	Formation and movement of ice in Delaware River and Bay, as observed during the winter of 1887-'88.
	12	Geodetic operations.	Prof. E. A. Bowser, acting assistant.	Continuance of reconnaissance and triangulation in the southern part of the State of New Jersey.

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION III.				
Maryland, District of Columbia, Virginia, and West Virginia, including bays, sea-ports, and rivers.	No. 1	Gravity work	E. D. Preston, subassistant; J. B. Baylor, assistant.	Determinations of gravity at the Smithsonian Institution, Washington, in connection with similar determinations in the Hawaiian Islands, and in California. (See "Special operations," also Section X.)
	2	Magnetic observations.	Charles A. Schott, assistant; Jas. B. Baylor, assistant.	Magnetic determinations (annual) at a station on Capitol Hill, Washington. (See also Section I.)
	3	Topography	John W. Donn, assistant; J. A. Flemer, aid.	Continuation of the detailed topographical survey of the District of Columbia.
	4	Topography	W. C. Hodgkins, assistant; R. E. Nelson, jr., Eberhard Fordan.	Continuation of the detailed topographical survey of the District of Columbia. (See also Section IV.)
	5	Topography and hydrography.	D. B. Wainwright, assistant......	Topographic and hydrographic resurveys on the eastern shores of Delaware, Maryland, and Virginia. (See also Section IV.)
	6	Triangulation	R. A. Marr, subassistant.........	Completion of the triangulation in the vicinity of Cape Charles, Va. (See also Sections I and XI.)
	7	Hydrography.....	Lieut. M. L. Wood, U. S. N., assistant.	Hydrographic surveys and examinations in the vicinity of Cape Charles, Va.
SECTION IV.				
North Carolina, including coast, sounds, sea-ports, and rivers.	No. 1	Special hydrography.	Lieut. Francis Winslow, U. S. N., assistant.	Special hydrography for the State of North Carolina completed.
	2	Triangulation, topography, and hydrography.	W. C. Hodgkins, assistant; D. B. Wainwright, assistant; R. E. Nelson, jr.	Additions to the triangulation, topography, and hydrography on the coast of North Carolina, between Beaufort and Cape Fear. (See also Section III.)
	3	Triangulation, topography, and hydrography.	D. B. Wainwright, assistant......	Connection of old with new triangulation on the coast of North Carolina, and resurveys on that coast from Masonboro Inlet towards New River Inlet. (See also Section III.)
SECTION V.				
South Carolina and Georgia, including coast, sea-water channels, sounds, harbors, and rivers.	No. 1	Hydrography.....	Lieut. J. E. Pillsbury, U. S. N., assistant.	Hydrographic survey of St. Simon's Bar, Georgia. (See also Sections I, II, and VI.)
SECTION VI.				
Peninsula of Florida, from St. Mary's River on the the east coast, to and including Anclote Anchorage on the west coast, with the coast approaches, reefs, keys, sea-ports, and rivers.	No. 1	Physical hydrography.	Lieut. J. E. Pillsbury, U. S. N., assistant; Ensigns N. J. Halpine, R. M. Hughes, A. G. Rogers, C. S. Stanworth, and J. E. Shindel, U. S. N.; Assistant Surgeon, T. A. Berryhill, U. S. N.; Passed Assistant Engineer, G. W. Cowie, jr., U. S. N.	Gulf Stream Explorations, 1888. Observations of currents outside the Bahama Islands; between the Great Bahama Bank and Cuba, in the Windward Channel; in the Mona, Anegada, and Windward Island Passages, and in the Equatorial Stream, between Barbados and Tobago. (See also Sections I, II, and V.)
	2	Hydrography....	Lieut. J. F. Moser, U. S. N., assistant; Ensigns Franklin Swift, W. O. Hulme, H. A. Bispham, and R. E. Evans, U. S. N.; Passed Assistant Surgeon J. M. Steele, U. S. N.; Assistant Engineer S. H. Leonard, U. S. N.	Hydrographic surveys on the west coast of Florida from Pavilion Key to Cape Sable, and thence to Sandy Key and Key West. (See also Section I.)
	3	Topography	Joseph Hergesheimer; assistant; J. H. Gray, aid.	Topographical survey of the west coast of Florida, between Pavilion Key and Cape Romano. (See also Section II.)
SECTION VIII.				
Alabama, Mississippi, Louisiana, and Arkansas, including Gulf coasts, ports, and rivers.	No. 1	Reconnaissance and triangulation.	F. Walley Perkins, assistant; W. B. Fairfield, extra observer.	Continuation of the reconnaissance and triangulation for connecting the primary triangulation near Atlanta, with that of the Gulf. (See also Section XIV.)
	2	Triangulation, topography, and hydrography.	J. Henry Turner, aid; E. M. Talcott, recorder.	Survey of the Mobile River from Spanish River to the junction of the Alabama and Tombigbee Rivers. (See also Section XVI.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION VIII—Continued.	No. 3	Geodetic leveling.	John E. McGrath, subassistant; John Nelson, aid; F. A. Young, recorder.	Lines of geodetic leveling run between the Mississippi River and Little Rock, Ark. (See also Sections II and XV.)
	4	Triangulation, topography, and hydrography.	C. H. Sinclair, assistant; E. L. Taney, subassistant; P. A. Welker, aid; J. A. Flemer, aid.	Triangulation, topography, and hydrography, of the Atchafalaya River and detached surveys on the coast of Louisiana. (See also Sections X, XI, and XVI, and "Special operations.")
	5	Topography	E. L. Taney, subassistant	Topographic surveys on the coast of Louisiana, between Vermilion Bay and Calcasieu Pass. Topographic survey of the Atchafalaya River, Louisiana. (See also Section I.)
	6	Hydrography	Lieut. F. H. Crosby, U. S. N., assistant; Ensigns R. O. Bitler, Joseph Strauss, D. S. Nes, U. S. N.	Hydrographic surveys on the coast of Louisiana, between Isle Derniére and Big Constance Bayou, including Vermilion Bay. (See also Section I.)
SECTION X.				
California, including the coast, bays, harbors, and rivers.	No. 1	Triangulation and topography.	Aug. F. Rodgers, assistant; Isaac Winston, subassistant; John E. McGrath, subassistant.	Resurveys and examinations in San Diego Bay and vicinity. Tertiary triangulation and topography between San Diego and San Pedro Bays.
	2	Special hydrography.	George Davidson, assistant; Ferdinand Westdahl.	Special hydrographic examinations at San Juan Capistrano, La Ballona, and at Newport and San Pedro Bays, California.
	3	Examination of base site.	George Davidson, assistant; Fremont Morse, subassistant.	Examination of the site selected for the measurement of a primary base-line near Los Angeles, Cal.
	4	Magnetic observations.	R. E. Halter, assistant	Magnetic record continued at the self-registering magnetic station at Los Angeles, Cal. Absolute measures of the magnetic elements made monthly.
	5	Tertiary triangulation and topography.	Stehman Forney, assistant; John Nelson, aid.	Tertiary triangulation and topography on the south coast of California.
	6	Primary triangulation; inspection of field-work, etc.	George Davidson, assistant; James S. Lawson, assistant; L. A. Sengteller, assistant; P. A. Welker, subassistant; Fremont Morse, subassistant.	Continuation of the main triangulation of Southern California and of the astronomical and magnetic observations connected therewith.
	7	Determination of latitude.	George Davidson, assistant; James S. Lawson, assistant; Fremont Morse, subassistant.	Observations for the latitude of the Lafayette Park Station, San Francisco, in connection with the main triangulation.
	8	Magnetic observations.	George Davidson, assistant; Fremont Morse, subassistant.	Occupation of the station Presidio of San Francisco for magnetic observations.
	9	Tidal observations.	George Davidson, assistant; Emmet Gray, observer.	Tidal record continued at the automatic tidal station at Saucelito, Bay of San Francisco.
	10	Longitude determinations.	Edwin Smith, assistant; C. H. Sinclair, assistant.	Exchanges of telegraphic signals for longitude between San Francisco, Cal., and Portland, Oregon. (See also Sections XI and XVI.)
	11	Determinations of gravity.	E. D. Preston, subassistant; C. B. Hill, J. E. Keeler.	Determinations of gravity at San Francisco and Mount Hamilton, Cal. (See also "Special operations" and Section III.)
	12	Triangulation and topography.	Louis A. Sengteller, assistant; P. A. Welker, subassistant; C. M. Allen, recorder.	Resurvey of Suisun Bay and tributaries, California.
	13	Triangulation, topography, and hydrography.	George Davidson, assistant; Ferdinand Westdahl.	Resurvey of Eel River Entrance, and of Salt River, California.
SECTION XI.				
Oregon and Washington Territory, including coast, interior bays, ports, and rivers.	No. 1	Topographical reconnaissance.	E. F. Dickins, assistant	Completion of the topographical reconnaissance of the coast of Oregon from Yaquina Bay to Cape Orford, and thence to Cape Sebastian.

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION XI—Continued.	No. 2	Topographical reconnaissance.	Cleveland Rockwell, assistant	Completion of the topographical reconnaissance of the coast of Oregon between Yaquina River and Tillamook Bay. Examination for light-house sites at Cape Lookout and Cape Meares.
	3	Telegraphic longitudes.	Edwin Smith, assistant; C. H. Sinclair, assistant.	Telegraphic longitude determinations between Portland, Oregon, and Walla Walla, Washington Territory, and between Walla Walla and Salt Lake City. (See also Section X.)
	4	Telegraphic longitudes.	Edwin Smith, assistant; R. A. Marr, subassistant.	Determinations of longitude by exchanges of telegraphic signals between Yaquina and Portland, Oregon, and between Portland and Seattle, Wash. Ter. Observations for latitude and the magnetic elements at Yaquina and for the magnetic elements at Portland. (See also Section X.)
	5	Topography	J. F. Pratt, assistant	Topographical resurvey of the water front at Astoria, Oregon, and resurvey and remarking of tidal bench-marks.
	6	Hydrography	Lieut. J. C. Burnett, U. S. N., assistant. Ensigns W. P. White, J. A. Bell, J. L. Purcell, N. S. Moseley, G. R. Slocum, and J. P. McGuinness, U. S. N.; Assistant Surgeon E. W. Auzal, U. S. N., Assistant Engineer R. I. Reid, U. S. N.	Hydrographic survey of Shoalwater Bay and its approaches, and offshore hydrography between that bay and Gray's Harbor. Examination of Yaquina Entrance, Oregon.
	7	Triangulation and topography.	J. F. Pratt, assistant	Continuation of the triangulation and topography of Saratoga Passage and the coast and harbors in the vicinity.
	8	Hydrography	Lieut. H. T. Mayo, U. S. N., assistant; Ensigns A. C. Almy, U. S. N., Pay Yeoman W. B. Edwards.	Hydrographic surveys of Saratoga Passage, Holmes Harbor, and of the northwest coast of Whidbey Island.
	9	Hydrography	Lieut. C. F. Forse, U. S. N., assistant; Lieut. H. T. Mayo, U. S. N.	Hydrographic surveys in Rosario Strait and Padilla Bay, Washington Territory.
	10	Triangulation and topography.	J. J. Gilbert, assistant	Continuation of the triangulation and topography of Bellingham and Samish Bays, and the islands in the vicinity. Connection of the triangulation of Rosario Strait with that of Bellingham Bay, and extension to the Gulf of Georgia.
SECTION XII.				
Alaska, including the coast, inlets, sounds, bays, rivers, and the Aleutian Islands.	No. 1	Hydrographic surveys.	Lieut. Commander C. M. Thomas, U. S. N., assistant; Lieut. De-Witt Coffman, U.S. N.; Ensigns A. N. Wood, J. H. Shipley, C. C. Marsh, M. L. Read, A. P. Niblack, A. M. Beecher, and J. D. McDonald, U. S. N.; Surgeon T. H. Streets, U. S. N.; Passed Assistant Engineer H. N. Stevenson, U. S. N.	Hydrographic surveys in Frederick Sound and vicinity, Southeastern Alaska.
	2	Tidal observations.	George Davidson, assistant; Fred. Sargent, observer.	Continuation of tidal record at the automatic tidal station at St. Paul, Kadiak Island, Alaska.
	3	Hydrographic reconnaissance.	Lieut. Commander H. E. Nichols, U. S. N., assistant.	Hydrographic explorations in Western Alaska.
SECTION XIII.				
Kentucky and Tennessee	No. 1	Triangulation	A. T. Mosman, assistant; W. B. Fairfield, extra observer; R. J. Meigs, recorder; E. E. Torrey, foreman.	Extension westward of the transcontinental triangulation near the 39th parallel in Kentucky and Ohio. (See also Sections II and XIV.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION XIII.—Continued.	No. 2	Geodetic operations.	Prof. A. H. Buchanan, acting assistant.	Geodetic operations. Occupation of stations for the connection of the triangulation of the State of Tennessee with the primary triangulation of the Coast and Geodetic Survey in Northern Georgia and Alabama.
SECTION XIV.				
Ohio, Indiana, Illinois, Michigan, and Wisconsin.	No. 1	Triangulation ...	A. T. Mosman, assistant; W. B. Fairfield, extra observer; R. J. Meigs, recorder; E. E. Torrey, foreman.	Extension to the westward of the transcontinental triangulation near the 39th parallel in Ohio and Kentucky. (See also Sections II and XIII.)
	2	Reconnaissance...	F. W. Perkins, assistant; W. B. Fairfield, extra observer.	Reconnaissance for the connection of the triangulation of the State of Indiana with the transcontinental triangulation near the 39th parallel advancing to the eastward in Indiana and to the westward in Kentucky. (See also Section VIII.)
	3	Triangulation and reconnaissance.	George A. Fairfield, assistant; F. H. Parsons, subassistant; W. B. Fairfield, extra observer; E. E. Torrey, foreman.	Extension of the transcontinental triangulation near the 39th parallel to the eastward in the State of Indiana.
	4	Topography	John E. McGrath, subassistant ...	Topographical survey of the site of the American Bottom Base, Illinois. (See also Sections II, VIII, and XV.)
	5	Geodetic operations.	Prof. John E. Davies, acting assistant.	Geodetic operations continued in the State of Wisconsin.
	6	Geodetic operations.	Charles O. Boutelle, assistant; Prof. J. E. Davies, acting assistant; G. E. Brown.	Observations for latitude and azimuth at a trigonometric station in Wisconsin. (See also Section XV).
	7	Special survey....	C. H. Sinclair, assistant.	Surveys and examinations at Burnt Island, Michigan. (See also Sections VIII, X, and XI.)
SECTION XV.				
Missouri, Kansas, Iowa, Nebraska, Minnesota, and Dakota.	No. 1	Geodetic operations.	C. O. Boutelle, assistant; Prof. W. R. Hoag, acting assistant.	Continuation of geodetic operations preliminary to a triangulation of the State of Minnesota. (See also Section XIV.)
	2	Geodetic leveling.	John E. McGrath, subassistant; Gershom Bradford, assistant; Isaac Winston, subassistant.	Transcontinental line of geodetic leveling carried westward from New Haven, Mo. (See also Sections II, VIII, and XIV.)
	3	Triangulation ...	F. D. Granger, assistant; F. H. Parsons, subassistant; T. O. Pulizzi, recorder; A. P. Barnard, foreman.	Occupation of stations for extending to the westward the transcontinental triangulation near the 39th parallel in Kansas.
SECTION XVI.				
Nevada, Utah, Colorado, Arizona, and New Mexico.	No. 1	Telegraphic longitudes.	Edwin Smith, assistant; C. H. Sinclair, assistant.	Determination by exchange of telegraphic signals for longitude of the line, Salt Lake City to Walla Walla. (See also Sections X and XI.)
	2	Triangulation	William Eimbeck, assistant	Occupation of stations for the extension eastward of the transcontinental triangulation near the 39th parallel in Utah.
SPECIAL OPERATIONS.......	No. 1	Gravity work.....	E. D. Preston, subassistant	Determinations of gravity on the Hawaiian Islands, at San Francisco, on Mount Hamilton, and at Washington, D. C.
	2	Special surveys...	C. H. Sinclair, assistant..........	Special surveys and examinations made at the request of the Department of State and with the approval of the Secretary of the Treasury, at Burnt Island, Michigan.

APPENDIX No. 2.—1888.

STATISTICS OF FIELD AND OFFICE WORK OF THE COAST AND GEODETIC SURVEY FOR THE YEAR ENDING JUNE 30, 1888.

	Total to June 30, 1887.	Total during fiscal year.	Total to June 30, 1888.
RECONNAISSANCE.			
Area, in square statute miles	383, 260	271	383, 531
Parties, number of	------------	4	------------
BASE-LINES.			
Primary, number of	14	0	14
Primary, length of, in statute miles	90	0	90
Subordinate, number of	132	1	133
Subordinate and bench measures, length of	511	8	519
TRIANGULATION.			
Area, in square statute miles	211, 022	18, 940	229, 962
Stations occupied for horizontal measures, number of	11, 845	555	12, 400
Geographical positions determined, number of	22, 748	961	23, 709
Stations occupied for vertical measures, number of	805	73	878
Elevations determined trigonometrically, number of	2, 032	149	2, 181
Heights of permanent bench-marks by spirit-leveling, number of	687	33	720
Lines of spirit-leveling, length of, in statute miles	3, 633	167	3, 800
Triangulation and leveling parties, number of	------------	26	------------
ASTRONOMICAL WORK.			
Azimuth stations, number of	205	11	216
Latitude stations, number of	334	10	344
Longitude stations, telegraphic, number of (including two stations re-occupied)	137	6	143
Longitude stations, chronometric or lunar, number of	110	0	110
Astronomical parties, number of	------------	10	------------
MAGNETIC WORK.			
Stations occupied, number of	732	27	759
Permanent magnetic stations, number of	------------	1	------------
Magnetic parties, number of	------------	7	------------
GRAVITY MEASURES.			
Home stations occupied, number of (including two stations re-occupied)	19	3	22
Foreign stations occupied, number of	14	1	15
Parties, number of	------------	1	------------
TOPOGRAPHY.			
Area surveyed, in square statute miles	31, 253	454	31, 707
Length of general coast, in statute miles	7, 299	390	7, 689
Length of shore-line, in statute miles, including rivers, creeks, and ponds	91, 383	2, 154	93, 537
Length of roads, in statute miles	45, 997	588	46, 585
Topographical parties, number of	------------	23	------------
HYDROGRAPHY.			
Parties, number of	------------	15	------------
Number of miles (geographical) run while sounding	410, 714	19, 912	430, 626
Area sounded, in square geographical miles	119, 567	11, 875	131, 442

APPENDIX NO. 2.—Continued.

	Total to June 30, 1887.	Total during fiscal year.	Total to June 30, 1888.
HYDROGRAPHY—continued.			
Miles run additional of outside or deep-sea soundings	75,336	9,936	85,272
Number of soundings	18,236,978	609,903	18,846,881
Deep-sea soundings	13,110	95	13,205
Deep sea temperature observations	12,920	----------	12,920
Current stations, number of	----------	6	----------
Deep-sea current stations, number of	----------	34	----------
Deep-sea subcurrent observations, number of	----------	1,237	----------
Deep-sea surface current observations, number of	----------	2,830	----------
Specimens of bottom, number of	13,015	305	13,320
Automatic tide-gauges established	87	1	88
Automatic tide-gauges discontinued	82	2	84
Parties doing tidal work exclusively	----------	4	----------
Parties doing tidal in connection with hydrographic work	----------	20	----------
Staff and box gauges established	1,866	78	1,944
Staff and box gauges discontinued	1,858	79	1,937
RECORDS.			
Triangulation, originals, number of volumes	5,025	334	5,359
Astronomical observations, originals, number of volumes	1,856	35	1,891
Magnetic observations, originals, number of volumes	670	2	672
Magnetic observations, originals, number of cahiers	----------	37	----------
Pendulum observations, originals, number of volumes	----------	9	----------
Duplicates of above, number of volumes	5,431	360	5,791
Duplicates of above, number of cahiers	----------	36	----------
Computations, number of volumes	4,181	2	4,183
Computations, number of cahiers	----------	272	----------
Hydrographic soundings and angles, originals, numbers of volumes	10,341	402	10,743
Hydrographic soundings and angles, duplicates, number of volumes	2,778	248	3,026
Tidal and current observations, originals, number of volumes	4,079	129	4,208
Tidal and current observations, duplicates, number of volumes	2,636	106	2,742
Aggregate years of record from automatic tide-gauges	258	5	263
Tidal stations for which reductions have been made	1,069	114	1,183
Aggregate years of record reduced	222	17	239
MAPS AND CHARTS.			
Topographic maps, originals	1,797	59	1,856
Hydrographic charts, originals	1,950	74	2,024
ENGRAVING AND PRINTING.			
Finished charts published from engraved plates, total number of	435	12	447
Engraved charts withdrawn from circulation	145	8	153
Engraved plates of preliminary charts, sketches, and diagrams for the Coast and Geodetic Survey reports, number of	667	1	668
Electrotype plates made	1,957	63	2,020
Charts published by photolithography, number of	----------	31	----------
Charts published by photolithography withdrawn from circulation	----------	9	----------
Engraved plates of Coast Pilot charts	80	0	80
Engraved plates of Coast Pilot views	91	7	98
Printed sheets of maps and charts distributed	628,832	41,322	670,154
Printed sheets of maps and charts deposited with sale agents	284,449	25,273	309,722

Appendix No. 3.—1888.

INFORMATION FURNISHED TO DEPARTMENTS OF THE GOVERNMENT IN REPLY TO SPECIAL REQUESTS, AND TO INDIVIDUALS UPON APPLICATION, DURING THE FISCAL YEAR ENDING JUNE 30, 1888.

Date.		Name.	Data furnished.
1887.			
July	2	Blackford, E. G., Commissioner of the survey of oyster territory, New York.	Geographical positions and descriptions of stations, north and south shores of Long Island Sound, from College Point to Fox Island.
	2	Welcher, M. P., Pleasantville, N. Y.	Geographical positions and heights of twelve prominent triangulation stations, mostly in New York State.
	5	Powell, J. W., Director U. S. Geological Survey	Geographical positions and descriptions of stations in the vicinity of Richmond, Petersburgh, Port Royal, Newport News, Norfolk, Lynchburgh, Warm Springs, Lexington, a number of mountain stations in the Blue Ridge, Virginia, and several in North Carolina.
	7	Kobbé, Gustav, "Mail and Express," 23	Data relating to observations and prediction of tides.
	8	Kiggins & Tooker Company, 123 and 125 William street, New York City, N. Y.	Data of publication of Pacific Coast Tide Tables for 1888.
	8	Powell, J. W., Director U. S. Geological Survey	Geographical positions and descriptions of stations in the vicinity of Baltimore.
	9	Webb, J. O., County Surveyor, Orange County, N. C	Magnetic declination observed at Raleigh and secular variation of the same.
	11	Branner, J. C., Director Geological Survey of Arkansas	Astronomical positions in Arkansas.
	18	Loomis, L. M., Chester, S. C	Height of several mountains in South Carolina, and advice respecting instruments for measuring heights of objects.
	19	De Camp, E. A., Los Angeles, Cal	Geographical positions in the vicinity of Los Angeles connecting coast with Magnetic Observatory.
	20	Kiggins & Tooker Co., 123 and 125 William street, New York City, N. Y.	A corrected proof of the tide predictions for San Francisco, Cal., for 1888.
	21	Fulton, R. B., P[illegible]of Mississippi	Four appendices on late magnetic researches by the Coast and Geodetic Survey.
	26	Fowler, C. E., Civ[illegible], Chillicothe, Ohio	Results of spirit-levels near the 39th parallel.
	26	Branner, J. C., State Geologist of Arkansas	Four communications, viz: Results of the triangulation of the Mississippi River near the southern boundary of Arkansas and in the vicinity of Greenville, Miss.; results of the triangulation of the Mississippi River between Helena and Memphis; description of bench-marks at Greenville, Miss., and descriptions of base-lines at Greenville, Miss., at Helena, Ark., and at Hopefield, Ark.
	30	Baldwin, H. L. U. S. Geological Survey	Geographical positions and azimuth and distance, Cedar to Jefferson City, Mo.
	30	Blackford, E. G., Commissioner of the survey of oyster territory, New York.	List of geographical positions, Fox Island to Old Field Point, Long Island.
Aug.	4	Blackford, E. G., Commissioner of Fisheries, New York.	Descriptions of stations, north coast of Long Island, between Fox Island and Old Field Point.
	5	Spofford, N., Civil Engineer, boundary survey of Massachusetts and New Hampshire.	Geographical positions in the vicinity of Powow, Mass.
	5	Creighton, Jos. Rigge, Observatory, Omaha, Nebr	Description of astronomical stations.
	8	Allen, C. H., Major U. S. Engineers	Geographical position of Brainerd, Minn.
	8	Branner, John C., State Geologist of Arkansas	Height of bench-mark at Greenville, Miss., above the Gulf level.
	9	Burton, A. E., Surveyor, Breezy Point, N. H	Position of Stinson station, and geodetic connection with Moosilauk Station.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1887.			
Aug.	12	Safford, J. S., State Geologist of Tennessee	Table of geodetic results, triangulation of the Mississippi River near Memphis, table of heights of bench-marks along the western boundary of Tennessee, astronomical positions determined in Tennessee.
	15	Bogart, J. P., Engineer for Boundary-Line Commission, Rhode Island and Connecticut.	Copy of triangle, Fort Hill, Frost, and Watch Hill.
	17	Safford, J. S., State Geologist of Tennessee	Results of geodetic survey of Tennessee.
	19	Todd, W. J., New York Oyster-bed Survey	Geographical positions and descriptions of stations in the vicinity of Lloyd's Neck, Long Island.
	19	Branner, J. C., State Geologist of Arkansas	Height of eighty-seven bench-marks along the Mississippi River and opposite eastern boundary of the State.
	20	Thornton, W. M., Professor of Engineering, University of Virginia.	Two pamphlets and chart on the distribution and secular change of the magnetic declination in the United States.
	23	Winslow, F., Lieutenant U. S. Navy	Geographical positions, Pond and Lighter, N. C.
	24	The City Engineer and Surveyor, San Diego, Cal	Height of granite bench-mark at La Playa, San Diego Bay, Cal., above the average of the lower low waters.
	26	Howell, E E., Rochester, N. Y	Geographical position and description of Station Luper, Tenn.
	29	Blackford, E. G., Commissioner of Fisheries, New York	Geographical positions of one hundred and seventy-one stations on Long Island.
	30	Quimby, E. T., Hanover, N. H	Position of Northfield Church, Massachusetts.
Sept.	1	Chataigne, J. H. & Co., Richmond, Va	Geographical positions and magnetic declinations of fourteen prominent stations in Virginia.
	5	Powell, J. W., Director U. S. Geological Survey	Geographical positions and descriptions of forty stations on the Patapsco River.
	7	Blackford, E. G., Commissioner of Fisheries, New York	Descriptions of one hundred and eighteen stations on Long Island, N. Y.
	8	Fitch, W. E., Civil Engineer, Holyoke, Mass	Descriptions of five trigonometrical stations in Massachusetts and height of Mount Tom.
	19	Spofford, N., Civil Engineer, Massachusetts and New Hampshire Boundary Survey.	Geographical position of Great Boar's Head and Salisbury Marsh, and certain azimuthal directions from the former station.
	19	Howe, C. S., Professor Astronomy, Buchtel College, Akron, Ohio.	Star places for 1887, for computation of latitude of observatory.
	22	Warner, Charles F., Civil Engineer, Farmington, Me	Two pamphlets on distribution of magnetic declination and the secular change, with addition of latest unpublished deductions.
	23	Hydrographic Office, Navy Department	Magnetic declination at Boston in 1845, and decennial values between 1700 and 1895.
	24	Sanford, O. N., City Engineer and Surveyor, San Diego, Cal.	Description of bench-mark at La Playa, San Diego Bay, Cal., with height above the average of lower low waters.
Oct.	1	Phillips, Prof. A. W., Yale College, Connecticut	Explanation of currents at New London, Conn., July 1, 1887.
	4	Stanton, W. S., Major U. S. Engineers	Magnetic declination at Prospect Harbor Light-House, Maine, in 1847, and at Bear Island Light-Station, Maine, in 1838.
	4	Alexander, W. S., Lieutenant U. S. A	Description of stations and geodetic data of eight stations in the vicinity of Fort Adams, [illegible]
	17	Schenck, M., Engineer, Hudson River Inspector	Heights of bench-marks, [illegible] Albany, N. Y.
	20	Berry, J. O., Ash Grove, Fairfax County, Va	Information respecting se[illegible]ion of magnetic declination, epoch of stationary condition, and present annual change.
	20	Schenck, M., Engineer, Hudson River Inspector, Office State Engineer and Surveyor, Albany, N. Y.	Relation of mean low water at Greenbush to mean low water at New York Harbor.
	24	Blackford, E. G., Commissioner of Fisheries, New York	Description and position of station Brow Hill, N. Y.
	26	Ford, W. G., Engineer New York oyster-bed survey	Geographical positions and descriptions of stations Glover, Osborn, Terry, Rutland.
	28	Kaufman, J. B., County Surveyor, Upper Strasburgh, Pa	Discussion of the secular change of the magnetic declination at Chambersburgh, Pa.
Nov.	1	Black, W. M., Captain U. S. Engineers	Results of triangulation, vicinity of Manatee River, Tampa Bay, Florida. Sketch of triangulation and description of stations.
	2	Chief of Engineers, U. S. A	Description of bench-mark at Palmetto, Manatee River, Florida.
	3	Cook, George H., Prof., State Geologist, New Brunswick, N. J.	Description of bench-mark, pier No. 2, Pennsylvania Railroad freight house, Jersey City, N. J.
	12	Pilling, J. C., Chief Clerk Geological Survey	Geographical positions of three points near St. Louis, Mo.
	12	Hamilton, T. A., Birmingham, Ala	Magnetic declination at Mobile between 1800 and 1890.
	18	Chief of Engineers, U. S. A	Description of bench-mark at St. Augustine, Fla.
	23	Abell, Rev. J. J., Cotesburg, Ky	Geographical positions of trigonometrical points in the vicinity of Louisville, Ky.
	25	Welling, W. Brenton, No. 2 Wall street, New York	Explanation of unusual tides in Narragansett Bay, November 20, 1887.
	30	Ewing, T., Columbia College	Geographical position of station "Ludlow," Yonkers, N. Y.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1887.			
Dec.	1	Williams, A. L., Surveyor, Aiken, S. C	Table of magnetic declination at Aiken between 1800 and 1890.
	2	Clark, S. C., 201 Stanton Place, Washington, D. C	Latitude and longitude of the Capitol and of the Washington Monument.
	6	U. S. Geological Survey	Two geographical positions, one in Alabama and the other in Georgia.
	10	U. S. Geological Survey	Description of station View Tree, Va.
	15	Ford, A. M., Salem, N. Y	Position of St. John's church, Salem.
	19	Pritchett, H. S., Director of Washington University, St. Louis, Mo.	Longitude of Seymour, Ind.
	19	Doyle, E. P., Clerk to Commissioner of Fisheries, State of New York.	Geographical position of station Morgan 2, Raritan Bay, New Jersey.
	19	McLeod, McGill University, Montreal	Height of trigonometrical station on Mount Royal, and of bench-mark Chapman's Block, Rouse's Point.
	21	Finley, Lieut. John P., Assistant Signal Officer	Matter relating to distances over which heliotrope signals are transmitted, height of station, size of reflectors, etc.
	21	Ford, Albert M., Salem, N. Y	Memorandum on duration of rise and fall of tide at Atlantic City, N. J.
1888.			
Jan.	4	Colvin, Verplanck, Superintendent State Land Survey, New York.	Geographical position of Pennsylvania Mountain and Mount Bigelow, and abstract of directions observed at these stations.
	5	Kimball, G., Civil Engineer, Newburgh, N. Y	Geodetic data of four trigonometrical points near Newburgh.
	6	Prince, George T., Secretary and Superintendent Atlantic City Water Works Company.	Present bearing of a line near Absecon, N. J., originally run in 1710.
	9	Prichett, H. S., Director of Observatory Washington University, St. Louis.	Approximate longitude of Birmingham, Ala.
	10	Donham, G. M., No. 185 Middle street, Oxford Building, Portland, Me.	Manuscript copy tide-tables, Portland and Boston, January, February, and March, 1889.
	12	Greenleaf, H. T., Surveyor and Engineer State Boundary between North Carolina and Virginia.	Geodetic and astronomical positions on Knott Island, North Carolina and Virginia.
	12	Cox, A. G., Wise Court House, Va	Table of secular variation of the magnetic declination between 1750 and 1890, and other needful information as to distribution of magnetism.
	12	Powell, J. W., Director Geological Survey	One hundred and eighteen geographical positions, distances and azimuths of the triangulation of the State of Wisconsin, complete to date.
	18	Dodge, W. W., 85 Milk street, Boston, Mass	Geographical positions in Norfolk County, Mass.
	20	Chief of Engineers U. S. A., for Board of Engineers in charge of New York Harbor Improvements.	Copy half-hourly ordinates, June 20 to August 10, 1887, Sandy Hook, N. J.
	21	Tuttle, F. J., Fremont, Ohio	Change of magnetic declination at Fremont between 1820 and the present time, and present bearing of an old compass line.
	21	Olney, S. A., Coleman's Falls, Bedford County, Va	Magnetic chart and pamphlet on secular variation.
	24	Taylor, M. P., Oxford, N. C	Present bearing of a line originally run in 1742 in Chowan County, N. C.
	28	Frick, Norris H., South Queen street, York, Pa	Information on theory of the tides.
Feb.	16	Bartlett, J. P., Commander U. S. N., Hydrographer	Change of the magnetic variation between 1820 and 1885, at the mouth of the North Penobscot River.
	17	Roer, F., Jefferson City, Mo	Spirit levels to St. Louis, and height of last bench-mark, at Etlah, Mo.
	20	Le Conte, S. J., Assistant Engineer U. S. A., San Francisco, Cal.	Description of two bench-marks at Benicia, and two at Mare Island, California, with reference to hydrographic datum plane.
	23	Cantain, Samuel S., Master Tug *Ocean King*, 56 Woodhull street, South Brooklyn, N. Y.	Rise and fall of tides each hour at Pollock Rip, Massachusetts, and Hell Gate, New York.
Mar.	1	Bartlett, J. R., Commander, U. S. N., and Hydrographer	Letter from George Davidson, assistant Coast and Geodetic Survey, giving magnetic declination coast of Mexico for 1714.
	2	Harkness, Wm., Professor, U. S. Naval Observatory	Comparison of yard metre No. 1, Coast and Geodetic Survey, with yard metre No. 2, Stevens' Institute.
	3	Hydrographer, U. S. N., Washington, D. C	Average rise of tides Portland, Oregon.
	6	Hinrichs, O., Civil Engineer, Washington, D. C	Geographical positions determined by the Coast and Geodetic Survey in the interior of the States of Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and District of Columbia.
	10	Taggart, Hugh S., Assistant District Attorney, Washington, D. C.	State of the tide every hour during the day time, March 11 and 12, 1888, East Branch Potomac, Washington, D. C.
	12	Mackie, Simon T., Salt Lake City, Utah	Reference to "n" point problem.
	12	Sadler, J. E., City Surveyor, Baltimore	Data for laying out a meridian line for projected extension of city limits.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1888.			
Mar.	12	Blackford, E. G., Commissioner of Fisheries, and in charge of survey of oyster territory of New York.	Geographical positions about the Upper Bay, New York, and in the vicinity of Kill van Kull and Arthur Kill.
	15	Director U. S. Geological Survey	Geographical position and description of three astronomical stations in Alabama and Georgia.
	15	Mendell, G. H., Colonel U. S. Engineers, San Francisco, Cal.	High and low waters, and half-hourly ordinates February, 1888, Saucelito, Cal.
	20	Henck, J. B., Montento, Cal	Position and description of eight triangulation stations in the vicinity of Santa Barbara.
	24	Craig, James S., Nicholas C. H., W. Va	Geographical position and height above sea of stations Summerville and Nicholas C. H.
	26	Director U. S. Geological Survey	Geographical position of station Pilot, N. C.
	26	Wheeler, J. C., Civil Engineer, Macon, Ga	Position of station and magnetic declination at Macon, and copy of Appendix No. 12, report of 1882.
	26	Mackie, S. F., Salt Lake City, Utah	Information respecting the "n" point problem.
	26	Knower, Edw. C., Captain, U. S. A	Geographical positions vicinity of Fort McHenry, Baltimore, Md.
	27	Blackford, E. G., Commissioner of Fisheries, and chief of survey of oyster territory, State of New York.	Geographical position of Great Captain's Island Light-House, of Bryam Point, rock at extreme point, of a point 600 feet south of this place, and the position of another light-house, Long Island Sound.
	27	Austin, W. W., Palmyra, N. Y	Explanation of tide tables, Philadelphia, 1888.
	30	Torry, Prof. J., Iowa College, Grinnell, Iowa	Results of weighings of a set of 21 metric weights.
	30	Cook, George H., Rutger's College, New Brunswick, N. J.	Comparison of a 50-foot steel tape.
	31	Taggart, Hugh S., Assistant District Attorney, Washington, D. C.	State of tide, 11 a. m., March 31, 1888, Navy-Yard, Washington, D. C.
Apr.	5	Bowen, P. A., Aquasco, Prince George's County, Md	Magnetic declination in Calvert County, and secular change since 1869, with present annual change.
	6	Rice, J. C., Mendocino, Cal	Appendix No. 12, report of 1882; Appendix No. 9, report of 1881, and table of magnetic declination at San Francisco and Cape Mendocino for each fifth year since 1850.
	10	Holmes, W. H., Philadelphia	Geographical positions in Massachusetts and Rhode Island (Appendix No. 8, report for 1885).
	11	Lowrie, J. L., Lloyd, Jefferson County, Fla	Magnetic declination at Lloyd, and annual change of declination.
	14	Chapell, T. C., Baltimore	Magnetic declination at Baltimore from 1668 to 1888.
	18	U. S. Geological Survey	Geodetic data for 360 trigonometrical stations in the State of Pennsylvania.
	19	.....do	Descriptions of nine trigonometrical stations in Rhode Island.
	20	Glenn, J. W., Engineer and Architect, New Orleans, La	Magnetic declination at Pascagoula in 1848, and at present.
	21	Stearns, C. W., Agricultural Department, Raleigh, N. C	Geographical position of Brown's Creek.
	30	Derby, Geo. McC., U. S. N., New York City, N. Y	Description, B. M., at San Lorato Asylum, Staten Island, N. Y.
	31	Chief of Ordnance, Frankfort Arsenal	Comparison of 18 rods and 8 cylindrical gauges for determining their lengths and diameters.
May	3	Monroe, Albert J., New London, Conn	Description of tidal bench-mark near New London, Conn.
	3	Barnard, L. N., State University of Pennsylvania	Example of least square adjustment of angles at a station and of a quadrilateral.
	7	Stanton, W. S., Major, U. S. Engineers	Magnetic declination at various old dates for seven light-house reservations, first and second districts, Massachusetts.
	10	Secretary of Department of Public Works, Iowa	Height of bench-mark at Rouse's Point, New York, above the average sea level.
	12	Stanton, W. S., Major, U. S. Engineers	Magnetic declination for old dates at four light-house reservations, first and second districts, Massachusetts.
	12	Winger, A. S., County Surveyor, Sylvan, Franklin County, Pa.	Table of secular variation between 1730 and 1895 for Franklin County, Pennsylvania.
	14	Chapman, R. P., Hartford, Conn	Information respecting measurement of arcs for the earth's figure by the Coast and Geodetic Survey, and from other sources.
	15	Sinclair, C. H., Washington, D. C	The magnetic declination at Detour, Mich., in 1815.
	17	Sorley, John, No. 122 East Seventy-fourth street, New York.	Length of the geographical mile.
	17	Ford, Albert M., Salem, N. J	Effect of winds on tides on coast of the United States.
	19	Lovick, H. I., Surveyor, New Berne, N. C	Sixth edition of secular change paper.
	20	Ranson, R., Surveyor, Seaview Canaveral, Fla	Copies of sixth edition of secular change paper and of Appendix 13, report for 1882.
	23	Lanphear, Geo. T., Peacedale, R. I	Geographical positions vicinity of Point Judith.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1888.			
May	25	Pritchett, H. S., Director of Observatory Washington University, St. Louis, Mo.	The latitude and longitude of the observatory, as determined astronomically by the Coast and Geodetic Survey.
	29	Hoxie, Capt. R. L., Pensacola Navy-Yard, Florida	Geographical positions and descriptions of stations, entrance to Pensacola Harbor.
June	2	Harkness, Professor Wm., U. S. N	Comparison made between Coast and Geodetic Survey standard 10-foot rod and the one on which the value of the Yale College transit of Venus photographs depend.
	2	Maxon, Frank O., Civil Engineer, U. S. N	Comparison of two tapes with Coast and Geodetic Survey standard.
	4	Beebé, Wm., Professor, Yale College, Connnecticut	Formation of derivative tide tables for New Haven and Bridgeport, Conn.
	6	Goode, R. V., Topographer, Geological Survey	Description of Station James in Rhode Island.
	9	Brackett, S. H., St. Johnsbury, Vt	Direction for measurement of terrestrial magnetism.
	14	Stanton, W. S., Major, U. S. N., Light-House Inspector	Magnetic declination at Monomoy Point, Palmer's Point, and East Chop, Massachusetts; for old dates.
	15	Mauro, L. J., Civil Engineer, Washington, D. C	Pamphlets on secular variation of the magnetic declination, dip and intensity.
	16	Williams, H. S., Harpursville	Pamphlet on secular variation and distribution of the magnetic dip and intensity in the United States.
	19	Acting Chief Clerk Geological Survey, Division of Geology.	Geographical positions of thirty triangulation points, vicinity of St. Louis, Mo., and their descriptions.
	19	Chief Hydrographer, U. S. N	Comparison of one tape with Coast and Geodetic Survey standard.
	20	Director of the U. S. Geological Survey	Height and description of bench-mark between Hudson and Lansingburgh.
	22	Rand, J. H., Vanceburg, Ky	Position of the agonic line with respect to Big Sandy River.
	22	......do	Geographical positions and geodetic data for three trigonometrical stations near Vanceburg, and position of the place.
	22	Bogart, J. P., Engineer to Fish Commissioners, Connecticut.	Thirty-nine geographical positions in Connecticut, between New Haven and Captain's Island.
	22	Seaman, W. H., Miller Manual Labor School, Crozet, Va	Six geographical positions, vicinity of Charlotteville.
	22	Director of the U. S. Geological Survey	Geographical positions and descriptions of stations near the eastern part of the boundary of Massachusetts and New Hampshire.
	25	Alexander, G. D., Surveyor, Shreveport, La	Magnetic declination at Shreveport in 1872 and change of the same between 1854 and 1872.
	26	Lanphear, G. T., Narragansett Pier, R. I	Descriptions of nine trigonometrical stations in Rhode Island.
	26	Director of the U. S. Geological Survey	Descriptions of seven geodetic stations in western part of New Jersey.
	27	Kimball, Geo., Newburgh, N. Y	Description of thirteen geodetic stations on the Hudson River.
	30	Fauth & Co	Comparison of two tape lines with Coast and Geodetic Survey standard.

APPENDIX No. 4.—1888.

REPORT OF THE ASSISTANT IN CHARGE OF OFFICE AND TOPOGRAPHY FOR THE YEAR ENDING JUNE 30, 1888.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, November 18, 1888.

SIR: I have the honor to submit my annual report for the Office, and along with it the annual reports of the various Divisions thereof.

The Computing Division has remained under the direction of its efficient chief, Assistant Charles A. Schott, who herewith submits a detailed report of its operations. I beg to call especial attention to the loss of some of our most skillful computers during the year, simply because sheer necessity drove them away, their salaries being so very small. Such computers as Mr. Courtenay and Mr. Doolittle, who have had years of training and whose services are invaluable, only receive eighteen hundred dollars per annum. I earnestly recommend that their salaries be increased to two thousand dollars per annum, and that similar increases be made for other deserving men in this line of occupation. Notwithstanding the loss of some of its best men, the Division has furnished the usual amount of information in answer to special calls. The results of the Connecticut Triangulation have been prepared for publication, and numerous appendices prepared for the annual report.

The Drawing Division has received the continued care of Assistant E. Hergesheimer, who has made excellent progress with the work. More charts have been published during this fiscal year than heretofore during the same length of time. Much progress has been made in the arrangement of the drawings, etc., onits files, and with additional help it will very soon be in thorough working order. The facts in the case of the output of our highest paid men in this Division go to illustrate the wisdom of getting first-class men and paying them enough, when trained, to prevent their abandoning the work. It is much to the credit of some of the draughtsmen that they have foregone, to a very great extent, their annual leave, preferring to help the work along by devoting to it their entire time. Such service is deserving of the best pay and the highest consideration.

The Engraving Division has remained under the skillful management of Assistant Herbert G. Ogden. Very satisfactory progress has been made in all of its operations. In Electrotyping and Photographing, Mr. D. C. Chapman has kept fully up to the work. His success in mounting a photograph on card-board to scale has been most gratifying and is a great relief to the Drawing Division. If our chart sales continue to increase as they have done during the past year, the force of plate-printers must be increased to enable us to keep up with the demands.

The Instrument Division has continued under charge of Assistant Andrew Braid, with Mr. E. G. Fischer as Chief Mechanician, and Mr. H. O. French as Chief Carpenter and Model Maker. The instrument and carpenter shops are now in as high a state of efficiency as they can be brought without increasing the force. With our plant and present facilities I would recommend the employment of about four apprentices at not exceeding six hundred dollars per annum each. These would in a short time be able to make all repairs, etc., and enable us to keep our skilled men on the much needed new work. Economy and excellence in Coast Survey field-work has its foundation in the Instrument Shop. Good and rapid work requires good instruments. We are now manufacturing all of our instruments and endeavoring to get our whole instrumental outfit in perfect repair. We have already advanced so far as to be able to supply any party that we are likely to be called upon to equip, with all necessary instruments in from one to three hours' notice. On general outlines given by Assistant Edwin Smith, the Chief Mechanician has constructed a pair of astronomical transits for our Telegraph Longitude work which are giving entire satisfaction and excellent results. Mr. Otto Storm, mechanician, did most of the work on them. Assistant Andrew Braid, Chief of the Instrument Division, himself an officer of great experience in leveling operations, furnished the general outlines of two levels of precision which have been constructed by the Chief Mechanician. The work on these was done chiefly by Mr. Theodore Gerhard. They have stood all of the office tests to our entire satisfaction, but it remains for them to be tried in the field.

The Instrument Division likewise has charge of the General Property of the Survey used in the field-work. It is now carefully looked after, and a satisfactory account can be given at any time of any part or the whole of it. The great improvement in the Instrument Division and its present high state of efficiency are very creditable to its Chief, Assistant Andrew Braid.

The Tidal Division has—considering its want of proper help—made excellent progress. Our Tide Tables are now out very nearly a year in advance. Its Chief, Mr. Alex. S. Christie, has been untiring in his attention to the work, and has been ably seconded by Mr. L. P. Shidy. The predictions have been extended to new points and improved at some of the old ones. There is yet much, in fact a very great deal, to be done, and adequate and proper force is absolutely necessary to do it, in the best interest of the public service. The remarks made with regard to the smallness of the salaries in the Computing Division are equally applicable to the Tidal Division.

The Miscellaneous Division has remained under the charge of General Office Assistant M. W. Wines. The various and complicated duties of this Division of the Office have been thoroughly mastered by its Chief. There is no position in the service requiring a greater amount of technical knowledge and its practical application than this. Almost any of the other Divisions of the Office can be filled creditably at once by various Assistants, but the knowledge of affairs and things required of the Chief of the Miscellaneous Division would have to be acquired, and the loss of his services would be felt as a serious inconvenience for a very long time. The labors of this Division of the Office have been largely increased of late, owing to our increased sales of charts, and its clerical force needs an increase in numbers and in pay.

The Chart Division has been organized during the year, and at my request Assistant William H. Dennis consented to take charge of it. He has been entirely successful in its management. His care and watchfulness have promoted its efficiency to such an extent that during the past six months an error on a chart issued by him has been almost unheard of. Few persons, even in the Survey, are aware of the patience and watchfulness required to bring this about. Our Chart Catalogue is superior to what it has heretofore been and is well kept up to date by hand corrections.

The Archives and Library, under Mr. A. Martin, has improved slowly. The cataloguing of the books in the Library is very nearly completed, and it is hoped that Mr. Martin will shortly be able to take up the cataloguing of the books distributed throughout the Office. The arrangement of the Records in the Archives by States has not yet been taken in hand and will not be until some one is available for the work who thoroughly understands our field-work, and can arrange the records without danger of confusion. The Division is, however, in better order than it was a year ago.

The Accounting Division has remained under charge of Mr. J. W. Parsons. The onerous duty of making disbursements on account of the U. S. Coast and Geodetic Survey has been continued with Mr. George A. Bartlett, Disbursing Clerk of the Treasury Department, and Congress has so far failed to compensate him in any way for this additional work and responsibility. Every consideration of justice demands that he should be paid for the service, and the amount estimated, $500 per annum, is hardly enough. Mr. J. W. Parsons has devoted his whole time, day and night, to the accounts and their adjustment. His system is about perfect, and the reports of the expenditure of the appropriation, rendered by him to the Superintendent and transmitted to Congress, are models well worthy of close consideration.

The Bureau of Weights and Measures, under the charge of Assistant O. H. Tittmann, has been put in order, and is daily growing in usefulness. We have just cause for pride in it. His report herewith is full of interest. We feel the want of a good comparing room very much, and one must be constructed in one of the vaults under the sidewalk in front of the building.

During the fiscal year ending June 30, 1888, the following-named persons have been employed under my immediate direction, constituting what is known as the "Office Division."

Dr. William B. French has acted as my immediate clerk in matters of executive detail; received moneys from sales of charts, publications, old property, and other sources, for which he has satisfactorily accounted to me; has aided in the Office correspondence, and has received all Office accounts and adjusted and arranged them on vouchers for my approval, retaining a set of duplicate bills. His service has been very efficient and entirely satisfactory, and he should receive at least eighteen hundred dollars per annum for the services rendered.

Mr. R. M. Harvey has filed the Office correspondence, received express and freight shipments, and attended to the reception and dispatch of registered mail matter. The infirmities of old age are telling on his once powerful physique, and his failing eye-sight may necessitate his assignment to other duty.

Miss S. C. Ayres has assisted in the Office correspondence, kept the leave of absence account book, prepared the monthly report of this Office, and otherwise been useful. Her services have been very acceptable and efficient.

Miss S. B. Harvie was engaged upon type-writing to the close of December, 1877, and was transferred to the Treasury Department January 1, 1888. Miss Harvie had become particularly skillful in her work and was much missed.

Miss K. Lawn used the type-writer during the whole year, rendering satisfactory work.

Miss F. Cadel was detailed from the Tidal Division to the Office Division July 5 and assisted in the Office correspondence until returned to the Tidal Division on October 3. On January 4 she was assigned to a type-writer and has since produced satisfactory work.

Mrs. Virginia Harrison was occupied in miscellaneous copying from August 1, 1887, to January 4, 1888, and was then transferred to the Tidal Division.

Mrs. M. E. Nesbitt was attached to the Office Division from January 4 to February 29, and was then returned to the Tidal Division.

Mr. Neil Bryant has been mainly engaged upon miscellaneous copying for the Office Division, but has occasionally assisted in clerical work for the Hydrographic Inspector and for Assistant Henry Mitchell.

Miss C. B. Turnbull was assigned to this Division from the Tidal Division March 1, and has addressed envelopes, copied instructions, indexed letter-books, and has done miscellaneous copying.

Mrs. J. L. Waddill having been assigned to this Office by Assistant Secretary (Thompson) of the Treasury, and paid by that Department, was engaged in duplicating field records, copies of which we are to furnish to the State of Massachusetts.

So far as I can ascertain, the Survey in the Field and in the Office was never in better condition than it is to-day. Harmony and good will reign throughout the organization, and employés vie with one another in the faithful performance of their respective duties. So far as this Office is concerned, its high state of efficiency is due to the Chiefs of the respective Divisions and their subordinates, to whom I take this opportunity of expressing my thanks.

The most cordial relations have existed between the Hydrographic Inspector and the Office, and our hearty co-operation has done much to facilitate and improve the work. We are particularly indebted to Lieut. M. L. Wood, U. S. Navy, Assistant to the Hydrographic Inspector, who has been untiring in his efforts to contribute to the perfecting of our charts in every detail. His suggestions have been found to have practical value in every instance, and it has been principally on account of his agitation of the matter that the Chart Division of the Office, which has proved so successful under the management of Assistant William H. Dennis, has been established.

Yours, respectfully,

B. A. COLONNA,
Assistant in charge of Office and Topography.

Mr. F. M. THORN,
Superintendent, Coast and Geodetic Survey.

REPORT OF THE COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE FISCAL YEAR ENDING JUNE 30, 1888.

COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE,
June 30, 1888.

DEAR SIR: In conformity with regulations, I have the honor to submit herewith the usual report of work done by the several computers, and others temporarily assigned to this Division of the Office during the fiscal year ending June 30, 1888.

The charge of the Computing Division was continued with the undersigned; the changes in the personnel, both of the permanent and the temporary force, since last year's report, were as follows: Mr. Alexander Ziwet handed in his resignation September 23, 1887, and Mr. Allan D. Risteen left, after serving but for two weeks, in July, 1887. In the resignation of Mr. Ziwet the Computing Division lost a very able computer; he was thoroughly acquainted with the methods of calculation, and possessed that general knowledge, which added so much to the value of his services. The training of a new computer for the variety of work placed in this Division of the Office is necessarily a laborious task, and one that can not be accomplished in the period of a year; in consequence, the Telegraphic Longitude Computations could not be resumed this year, and the force of the Computing Division was further strained by the reduction of geodetic levelings, which demand much time. On September 6, 1887, Mr. F. M. Little was assigned to the Computing Division, and on November 1, 1887, Mr. Louis A. Bauer was assigned to duty; the latter, after a satisfactory probationary term of six months, was permanently connected with the Division. Temporary help was given as follows: Assistant J. B. Weir, between October 5, 1887, and February 29, 1888; Assistant G. A. Fairfield, between March 3 and May 9, 1888, and Assistant J. B. Baylor, between May 1 and June 2, 1888. Respecting the needs of this branch of the Office, a computer to take care of the accumulated magnetic records at Key West, Fla.; at Madison, Wis., and at Los Angeles, Cal., and to compute and assist me in discussing and preparing the results for printing these observations, is very urgently demanded, and the necessity of an additional geodetic computer can only partially be satisfied by the assignment of temporary help from the field force. There is much valuable material accumulating which ought to be made ready for the printer, and, in connection with this, I am pleased to be able to state the completion of the final reduction of the triangulations made in Connecticut between 1833 and 1886, comprising about eight hundred geographical positions, which are proposed for publication in this year's report; this work is arranged similarly to the list of geographical positions in Massachusetts and in Rhode Island, published as Appendix No. 8 to the Report for 1885.

The Office correspondence relating to professional or scientific matter, which is generally referred to this Division, was promptly attended to. Besides directing, distributing, supervising, and reporting the work performed by the several computers, I gave special attention to the following subjects:

A report (for publication) on the results of spirit-leveling between Mobile, Ala., and New Orleans, La., 1885-'86; a report on the height above sea of St. Louis, Mo., by three independent routes; a statement of astronomical, geodetic, and magnetic work proposed for the Survey for the next fiscal year; a paper (for publication) on the average height of Lake Champlain and on the magnitude of the fluctuations in its level, during a number of years; a paper (for publication) giving an account of the development of the magnetic work of the Survey since its beginning; a report (for publication) of the results from spirit-leveling in the vicinity of New York Bay and Harbor, 1886-'87; a paper on the construction of isogonic curves for our Atlantic coast at the epochs, A. D. 1700 and 1750; an examination of the value of a nautical work, "The Arcano del Mare," Florence, 1646, respecting magnetic information; a paper on the secular change of the position of the agonic curve of the North Atlantic between A. D. 1500 and 1900; a report on the results of the main triangulation on the coast of California, between the Golden Gate and Santa Barbara Channel.

I also computed the astronomical azimuths at stations Money Point and Alpha, N. C., and made the first computation for time and azimuth at three coast stations, Oregon, 1887; brought the computation for the secular variation of the magnetic declination up to date, and attended to usual statistics (astronomical and magnetic), and to proof-reading.

The work performed by each computer during the fiscal year is herewith presented in detail, as made up from the daily and monthly reports.

Edward H. Courtenay completed the adjustment of the several triangulations of the Patapsco River, and of the vicinity of Baltimore, between the years 1842 and 1886; adjusted the old and new triangulations (1886) of Core Sound and of Beaufort Harbor, N. C., aided in the re-computation of the old triangulation between Beaufort and Cape Fear, N. C., basing the same on modern standard data, and completed the final adjustment of the several triangulations in the State of Connecticut between 1833 and 1886, a work of great magnitude and complexity. He also adjusted and based on standard data, the triangulation of the western coast of Florida, between Charlotte Harbor and Cedar Keys; had charge of the Computing Division for two weeks during my absence, prepared geodetic data for use by field parties, and in response to calls by correspondents; had charge of the geographical registers and of the duplicate records of the Survey relating to astronomy, geodesy, and magnetism, prepared part of the geodetic statistics, and supervised the work of Mr. Little and Mr. Maupin.

Myrick H. Doolittle computed the following triangulations: Of Santa Catalina Island, Cal.; of Willamette River between its mouth and Portland, Oregon, 1883; of the coast of Louisiana, west of Barataria Bay, 1886–'87; adjusted and based upon standard data the main triangulation between Cape Florida and Cape Sable, and re-computed on standard data the intervening subordinate triangulations, 1854–'87; computed the triangulation between Cape Sable and Cape Romano, Fla., 1886–'87, and computed the line measures up this coast to Tampa Bay; adjusted the triangulation of Monterey Bay, Cal. (1852–'84), and of the coast from Santa Cruz to Point Año Nuevo (1864); computed the Blue Buck base-line, Louisiana, 1883; prepared abstract of horizontal directions at primary station Mocho, Cal., 1887; adjusted the main triangulation of the coast between the Golden Gate and Santa Barbara Channel, involving the establishment and solution of forty-three normal equations, and assisted in the preparation of geodetic statistics.

Charles H. Kummell assisted Mr. Courtenay and Mr. Doolittle in the solution of normal equations in connection with the final adjustment of the triangulations of Connecticut and in southern California; computed the geographical positions of the following triangulations: Of the coast of Oregon, between Umpqua River and Coos Bay, 1882–'85; of the Gulf of Georgia, Wash. Ter.; of Charlotte Harbor, Fla.; of the State Survey of Wisconsin, 1885; of the James River, between City Point and Richmond, 1852–'80, basing the same on standard data; computed the triangulation of the Mississippi River Commission to fill up the gap between Greenville, Miss., and Helena, Ark., 1880–'81, basing it on our standard data; computed the triangulation of St. John's River, Florida, 1885, and attended to miscellaneous geodetic computations and revisions.

Henry Farquhar completed the reduction of the astronomical latitudes of five stations on the Virginia and North Carolina boundary, 1886–'87; computed the latitudes of four secondary stations in Kentucky and Illinois, 1882, and of Little Rock, Ark., 1882, and made progress with the reduction for latitude of seven secondary stations in Kentucky, Tennessee, Indiana, Illinois, and West Virginia. 1883. Mr. Farquhar also supplied the mean places of stars required by field parties; and made satisfactory progress with the star places required for fourteen latitude stations of the Hawaiian survey, 1887, undertaken with a view of studying the remarkable local deflections of the plumb line in these islands. The total number of stars for which north polar distance is required is 565, and these are selected and discussed, using all available star-catalogues, and they are adapted as near as may be to the standard places of Auwers.

Alexander Ziwet computed the astronomical azimuths of Station Tassel, N. Y., 1880, and Station Howlett, N. Y., 1883, and had nearly completed the computation of the telegraphic difference of longitude, Colorado Springs, Colo., and Kansas City, Mo., 1885, at the date of his resignation in September, 1887.

John B. Boutelle was chiefly engaged in various revisions of abstracts of angles, and in computing triangle sides and geographical positions in connection with the final adjustment and computation of the triangulations in the State of Connecticut and adjacent parts of New York, and of Clearwater Harbor, Fla.; he also supplied copies of reports of a professional character.

Allan D. Risteen served as a computer for two weeks and was engaged in the computation of geographical positions, vicinity of Baltimore, Md.

William C. Maupin was engaged in copying descriptions of stations for field parties, and in inserting results of geographical positions in the Office registers; he attended also to miscellaneous copying and conversions of measures and verifications.

Frank M. Little revised angles and computed triangle sides and geographical positions in New York, Connecticut, and North Carolina (Beaufort to Cape Fear), under the direction of Mr. Courtenay; computed a number of geographical positions in Tampa Bay and on the west coast of Florida up to Cedar Keys; after the middle of March he was engaged on the Office computation of the spirit-levels between Wilkerson's Landing, Miss., and Little Rock, Ark., 1887–'88; this is now very nearly completed.

Louis A. Bauer was engaged in the reduction of spirit-levels about New York Bay and Harbor, Staten Island, 1887, and Governor's Island to Throg's Neck, 1886–'87; made the reduction of the spirit-levels between Mobile and Citronelle, Ala., 1884, and between Meridian and Okolona, Miss., 1884; computed the time and azimuth at three stations in Oregon; computed the astronomical azimuths at thirty stations in connection with the magnetic declinations observed in 1887; assisted me in the solution of normal equations connected with my discussion of the secular variation of the declination and in proof-reading of my report on the magnetic work done at Fort Conger, 1881–'84, by Lieutenant Greely and party; attended to some geodetic revisions, reduced the spirit-levels between Meridian and Quitman, Miss., 1886, and made satisfactory progress with the reduction of the spirit-levels between Quitman and Citronelle, Ala., 1887.

John B. Weir, assistant, computed the levels about New York Bay and Harbor, 1887, from observations made by Subassistant McGrath.

George A. Fairfield, assistant, prepared abstracts of angles and directions of the triangulation of the coast of Louisiana east of Sabine Pass, 1883.

James B. Baylor, assistant, tested the figure of the axles of the dipping needles of Circle No. 20; reduced the magnetic observations at two stations in Michigan, and computed some positions on the upper part of James River, Virginia.

I remain, sir, yours very respectfully,

CHAS. A. SCHOTT,
Assistant in charge Computing Division.

Mr. B. A. COLONNA,
Assistant in charge Office and Topography.

REPORT OF THE ENGRAVING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR ENDING JUNE 30, 1888.

U. S. COAST AND GEODETIC SURVEY OFFICE, ENGRAVING DIVISION,
Washington, August 15, 1888.

SIR: I respectfully submit the following report on the operations of the Engraving Division during the fiscal year ending June 30, 1888.

The statistics are as follows:

ENGRAVING.

Number of new charts published, printed from copper plates	12
Number of new editions of charts printed from copper plates	10
Number of new sketches and illustrations printed from copper plates	8
Number of new charts commenced	7
Number of new editions of charts commenced	13
Number of new sketches and illustrations commenced	1
Number of copper plates corrected for printing charts	557
Number of copper plates corrected for printing sketches and illustrations	39
Number of unfinished plates on hand:	
Charts	36
New editions	10
Sketches and illustrations	19

ELECTROTYPING.

Number of pounds of copper deposited		1,628
Number of square inches on which deposit was made		66,132
Number of copper plates made:		
Basso	32	
Alto	31	
		63

PHOTOGRAPHING.

Number of negatives made	133
Number of prints made	723

PRINTING.

Number of impressions for Chart-room	32,345
Number of impressions for Assistant in charge of Office	1,893
Number of impressions for Engraving Division	1,822
Number of impressions for Hydrographic Inspector	1,284
Number of impressions for lithographers (transfer proofs)	111
Number of impressions for Atlantic Coast Pilot	6,638
Total number of impressions	44,093

The impressions for the Chart-room were printed from six hundred and sixty-four plates, of which number five hundred and fifty-seven required miscellaneous corrections applied to them before the impressions could be taken.

The engravers were employed during the year principally as follows: H. M. Knight, A. Petersen, J. G Thompson, and R. F. Bartle, jr., on lettering; H. T. Knight and H. L. Thompson on outlines and lettering; W. A. Thompson, R. F. Bartle, and H. C. Evans on topography and sand; J. Enthoffer on topography; E. H. Sipe on miscellaneous collections and additions and lettering; and T. Wasserbach and W. H. Davis on miscellaneous corrections and additions. There have also been employed at different times during the year, under the appropriations for extra engraving and the "urgent deficiency bill," that became available in April, Messrs. J. P. Cox, J. C. Entwistle, E. J. Enthoffer, E. Von Logau, and E. A. Maedel on lettering, and W. H. Dougal on correction of views illustrating the Coast Pilot.

All the engravers employed in the Office have at times been engaged on the miscellaneous corrections and additions applied to the plates before printing, that arise from changes in the aids to navigation, hydrographic examinations, re-surveys, etc. This class of work is always one of great urgency in order that the supply of corrected charts may be maintained for the use of the public. The five hundred and fifty-seven plates corrected during the year in these particulars involved a large amount of labor to the engravers, and consumed a considerable portion of the time in the Office of the Division in their verification and record.

The year's work shows a number of important charts completed, of which "The Delaware Entrance," from the re-surveys; The Cape Fear River, with the recent improvements by the U. S. Engineers; The Columbia River to Portland; A General Chart of the Pacific Coast from Pt. Arena to Cape Mendocino, and additions of the recent off-shore hydrography to the General Charts of the Atlantic coast from the capes of the Delaware to Cape Hatteras, are the most worthy of notice. The work executed under the "urgent deficiency bill" has also advanced the most important of the unfinished plates to a state of progress that promises favorably for fruitful results in the coming year. Had this appropriation become available a few months earlier it would have made a more marked increase in the output of the year, but the number of plates that could be finished in the short three months after it passed was too limited to make much impression with completed work; the aggregate of engraving that was accomplished, however, in forwarding important charts, has been very material.

The work in the Electrotype and Photograph rooms has been performed most satisfactorily by Mr. D. C. Chapman, assisted by Mr. L. P. Keyser. The amount of copper deposited has not been so large as in former years, as the work has been confined entirely to our own necessities. Some changes have been made in the arrangement and care of the batteries that it is believed will show a greater economy in their use, but as comparative results from their actual working are slow of attainment, a detailed statement must be deferred for the present. Many improvements have been made by Mr. Chapman since taking charge of the work, the most important of which I have noticed in my successive annual reports; but that they may be a matter of record for future reference, Mr. Chapman has summarized them in a special report dated July 17, 1888, a copy of which I have the honor to transmit herewith.

The machine for filing the backs of the electrotype plates, devised by Mr. Chapman and erected about six months ago, has proved very satisfactory, furnishing a smooth, even surface at a much reduced expenditure of time and labor, and finishing the plates in a more suitable condition for printing.

The system of mounting photographic prints to scale has continued in successful operation, and an exhibit of the method has been prepared at the request of the Secretary of the Smithsonian Institution, to form a part of an exhibit at Cincinnati by the Institution, showing the progress and applications of photography.

In compliance with your directions, experiments have been made by Mr. Chapman in gilding weights made of the Hassler brass. A very handsome gilt has been obtained by immersing the weights in a hot bath of pyrophosphate of soda and chloride of gold, but it is yet to be determined if the gilt is enduring and in all respects suitable for the purpose.

The Plate Printing Office has been conducted as heretofore by Mr. F. Moore, foreman, with Messrs. Hoover, Beck, and Crawford as printers, and Messrs. Troutman, Shelton, and Dickson as helpers, the latter having been appointed to the Office April 21, 1888, at the time Mr. Shelton was relieved. This class of work is laborious and exacting, and it is therefore gratifying to find the year's output for the Chart-room thirty-two thousand three hundred and forty-five impressions, a larger number than for any preceding year. As outlined in a report several years ago, the demand on the Printing Office is steadily on the increase. This is due, primarily, to two causes, the charts become more widely distributed, increasing the number of persons who use them, and new charts are constantly being added to the list from which additional prints must be furnished. If the demand were equalized over the year we should be fully able to supply it with our present force, but unfortunately during the summer months it far exceeds the other seasons, and the nature of the matter to be supplied precludes the possibility of providing it in advance during the duller months. During May, June, and July the presses turned out more work for the Chart-room than during the same months for any previous year, and yet we were constantly behind the orders on many of the standard charts, and within a few days it has been found necessary to start the fourth press by the employment of temporary labor, which will have to be continued until the pressure is relieved. It is hoped the addition of motive power to the presses will be fully accomplished during the current year, as that will afford a great measure of assistance, but at the same time we should not lose sight of the fact that this class of work increases naturally, and that it can not be long before the force will have to be supplied to run the fourth press continuously.

The clerical work of the Division has been maintained by Mr. John H. Smoot with his usual energy and precision, and reflects great credit to his ability and perseverance.

Assistant Edwin Smith reported to me for special duty in the Division on January 4, 1888, and was immediately assigned the work of cataloguing the engraved copper plates. I have had such a catalogue in contemplation for several years, and had gradually obtained proofs of the old plates as opportunity offered, until the data had been collected that would warrant work on the catalogue as soon as some one could be made available to take it up. It was therefore a source of great pleasure to me when Mr. Smith was assigned to the Division for this purpose. He continued on the duty until April 3, 1888, when his services were required in the field. A rough draught of the catalogue was completed and books have been ordered for the fair copies.

The records of the Engraving Division show the inception, time, cost, and completion of each engraving, and fully satisfy the requirements for the work of the Division. But as they are divided into day books, correction books, time and cost ledgers, and historical records, with the single purpose of recording the history of each plate, they are not in a geographical sequence to give a concise abstract of the work representing a particular locality. The frequent demand by engineers for copies of our original surveys and re-surveys, for comparison with recent work, led me to believe that a catalogue of the engraved work that could be furnished, arranged by localities, would be instructive as well as very useful. It should be remembered, in this connection, that our chart catalogue contains only the standard charts of the surveys that are reliable at the present time; that charts representing surveys that are obsolete, are condemned and speedily dropped out of the chart catalogue, and that there is, therefore, no publication of the Survey that shows the engraved material of the past that is available for study and comparison.

On April 7, 1888, one hundred and eighty copper plates were received from the Public Printer, representing a mass of miscellaneous material that I have not yet been able to classify, owing to the great demand on the Printing Office for charts having prevented getting proofs of all the plates up to this time. The plates thus far examined were in very bad condition, not having been properly protected when last printed. These plates will be listed and reported to you at the earliest opportunity.

The Office has also received from Mr. D. McClelland, April 21, 1888, a copper-plate engraving of the city of Washington, that has been designated a copy of the Boston plate, and I believe completes the resurrection of the early copper plates of the plan of the city, except the original Boston plate. I transmit herewith the customary list of plates completed, continued, and commenced during the year, and I have the honor to remain,

Yours, very respectfully,

HERBERT G. OGDEN,
Assistant U. S. Coast and Geodetic Survey,
In charge of Engraving Division.

B. A. COLONNA, Esq.,
Assistant in charge of Office.

REPORT OF MR. D. C. CHAPMAN, ELECTROTYPING AND PHOTOGRAPHING BRANCH OF THE ENGRAVING DIVISION.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, July 17, 1888.

DEAR SIR: In compliance with your request of June 30, asking for a statement of the results of various experiments I have conducted in this Department, I respectfully submit the following:

When I was assigned to the Photograph and Electrotype Department of your Division there was a desire to have the maps reduced by photography and mounted on card-board to the exact scale required in the transfer to the copper to be engraved. After a few days' study of the subject and a few experiments, I devised a frame for the purpose, by the aid of which a map may be photographed and mounted to a reduced scale in very much less time than had been done heretofore, as attested by the large amount of this class of work that has since been done by this method.

STEEL FACING.

In my first attempt at steel facing I found that a part of the current jumped from the iron anode to the lead lining of the vat (holding the solution) and passed around to the back of the cathode, making the deposit on the face of the cathode slow and uncertain, and also reducing the strength of the solution by not having sufficient anode surface.

To obviate this I put another anode at the back of the cathode; also put a piece of board at the back of the cathode between it and the anode, and have since then had no trouble in making a clean hard deposit.

SCRAP ZINC.

In the use of the battery for electro deposition I found that there was an accumulation of scrap zinc covered with mercury, which heretofore had not been utilized. To make use of this I have devised and made a frame for holding this material in the battery so that the zinc could be freely used up, and leaving the mercury, which is used again, thus avoiding either waste of zinc or mercury.

SILVERS AND CARBONS IN THE BATTERY.

Experiments for the purpose of determining the relative efficiency of the platinized silvers and the carbon plates used in the battery have shown that the platinized silvers deposit more than double the amount of copper that the carbons do, the deposit with the silvers being two hundred and thirty grains per hour, while the carbons gave only ninety grains per hour. I found that it required three times the amount of acid with the carbons that it did with the silvers to produce approximately the same deposit, or nearly three times the amount of zinc and carbon surface in the same solution.

RENEWING THE BATTERY.

I found that the method of renewing the battery by emptying the cells and making up an entire new solution did not give the best results, so I leave a portion of the zinc sulphate in the cells and add acid and water whenever they require to be strengthened, which gives less internal resistance and a more uniform rate of deposit.

TESTING THE CONDUCTIVITY.

I have made several experiments to test the conductivity of the copper electrolyte, and found that the best results were obtained by using a solution of fifty to sixty grains of copper crystal to the ounce of water and one-twentieth part sulphuric acid, so we get from the same battery considerable more copper deposited per day than we did with the old electrolyte.

FILING-MACHINE.

The labor of filing the plates apart by hand, and great delay in delivery of the work that sometimes ensued, induced me to devise a machine to assist in this work (the power being already at hand in the adjoining room). The machine has been in operation now about five months, and has proved very satisfactory, reducing the time required in filing the plates fully fifty per cent.

Yours, very respectfully,

D. C. CHAPMAN.

Mr. H. G. OGDEN,
Assistant in charge of Engraving Division.

Engraved plates of charts completed, continued, or commenced during the fiscal year ending June 30, 1888.

1. Outlines. 2. Topography. 3. Sanding. 4. General lettering.

Catalogue No.	Plate No.	Title.	Scale.	Engravers and work.
		NEW CHARTS COMPLETED.		
124	1884	Delaware entrance	1-80000	3. W. A. Thompson. 4. J. G. Thompson and A. Petersen.
150	1841	Masonboro Inlet to Shallotte Inlet, including Cape Fear	1-80000	3, 4. H. M. Knight.
176	1848	Lemon Bay to Tampa Bay	1-80000	3, 4. H. M. Knight and E. H. Sipe.
305	1821	Nash Island to Schoodic Island	1-40000	1, 2. R. F. Bartle. 3. H. C. Evans. 4. A. Petersen and E. H. Sipe.
424	1892	Cape Fear River from entrance to Reeves Point	1-40000	1, 2, 3. R. F. Bartle. 4. H. M. Knight, J. G. Thompson, A. Petersen, and R. F. Bartle, jr.
425	1890	Cape Fear River, Reeves Point to Wilmington	1-40000	3. R. F. Bartle. 4. H. M. Knight, A. Petersen, and R. F. Bartle, jr.
455D	1888	St. John's River, from Tocoi to San Mateo	1-40000	3. R. F. Bartle. 4. H. L. Thompson.
641B	1978	Columbia River, No. 4; Grim's Island to Kalama	1-40000	1, 3. W. A. Thompson. 3. H. C. Evans. 4. H. M. Knight, A. Petersen, and H. T. Knight.
641C	1867	Columbia River, No. 5, Kalama to Fales Landing	1-40000	3. H. C. Evans. 4. H. M. Knight, A. Petersen, and H. T. Knight.
641D	1868	Columbia River, No. 6, Fales Landing to Portland	1-40000	3. W. A. Thompson, H. C. Evans. 4. H. M. Knight, A. Petersen, and H. T. Knight.

Engraved plates of charts completed, continued, or commenced, etc.—Continued.

Catalogue No.	Plate No.	Title.	Scale.	Engravers and work.
		NEW CHARTS COMPLETED—continued.		
677	1818	From Point Arena to Cape Mendocino	1-200000	1. W. A. Thompson. 4. J. G. Thompson and A. Petersen.
690	1966	Commencement Bay and City of Tacoma	1-20000	1, 3. W. A. Thompson. 1, 2. R. F. Bartle. 4. E. H. Sipe.
		NEW EDITIONS, 1887, COMPLETED.		
9	1945	From Cape May to Cape Henry	1-400000	3. H. M. Knight. 4. J. G. Thompson, A. Petersen, T. Wasserbach, and H. T. Knight.
10	1714	From Cape Henry to Cape Lookout	1-400000	4. J. G. Thompson.
106	1925	From Kennebec entrance to Saco River	1-80000	3. W. A. Thompson and Wasserbach. 1. J. G. Thompson, T. Wasserbach, and W. H. Davis.
127	1200	From Cape May to Isle of Wight	1-80000	3, 4. T. Wasserbach. 4. E. H. Sipe.
190	1943	From Round Island to St. Joseph's Island	1-80000	1, 3. T. Wasserbach.
480	1889	Cedar Keys	1-50000	3, 4. E. H. Sipe and W. H. Davis.
659	1948	Tillamook Bay	1-20000	3. W. A. Thompson. 4. H. L. Thompson.
		NEW EDITIONS, 1888, COMPLETED.		
205	1216	Galveston Bay to Oyster Bay	1-80000	3, 4. W. H. Davis.
207	1334	Matagorda Bay	1-80000	3, 4. T. Wasserbach.
208	1849	Pass Cavallo, Lavaca, and San Antonio Bays	1-80000	3, 4. T. Wasserbach.
		MISCELLANEOUS COMPLETED.		
		Atlantic Coast Pilot Views:		
	1733	St. Catherine's and Sapelo Sounds		4. H. T. Knight.
	1735	Doboy and Altamaha Sound		4. H. T. Knight.
	1737	St. Simon's Sound and City of Brunswick		4. H. T. Knight.
	1739	St. Andrew's and Cumberland Sounds		4. H. T. Knight.
	1732	Warsaw and Ossabaw Sounds		4. H. T. Knight.
	1759	St. John's River Entrance		4. H. T. Knight.
	1788	St. Augustine Entrance		4. H. T. Knight.
	1965	Index Map, No. 8, Subsketch, No. 29		1, 4. H. T. Knight.
		NEW CHARTS COMMENCED.		
114	1969	Point Judith and Block Island to Plumb Island	1-80000	1. Joseph Enthoffer. 4. A. Petersen.
123	1974	Absecon Inlet to Cape May	1-80000	1, 2. Joseph Enthoffer. 4. A. Petersen and R. F. Bartle, jr.
125	1995	Delaware Bay and River, Cross Ledge to Reedy Point	1-80000	1, 2. Joseph Enthoffer. 4. A. Petersen.
211	1959	Laguna Madre, Texas	1-80000	1, 2. H. C. Evans.
303	1984	Moose Cove to Englishman's Bay, including Machias Bay.	1-80000	1, 2. Joseph Enthoffer. 4. A. Petersen.
610	1979	Wilmington and San Pedro Harbors	1-40000	1, 2. H. C. Evans. 3. R. F. Bartle. 4. R. F. Bartle, jr.
686	1996	Puget Sound, Washington Territory	1-80000	1, 2. Joseph Enthoffer.
		NEW EDITIONS COMMENCED.		
111	1991	Monomoy and Nantucket Shoals to Muskeget Channel	1-80000	1, 2, 3. H. C. Evans. 4. A. Petersen.
127	1983	Cape May to Isle of Wight	1-80000	1, 2. R. F. Bartle. 4. A. Petersen and R. F. Bartle, jr.
204	1900	Galveston Bay	1-80000	3, 4. W. H. Davis.
205	1216	Galveston Bay to Oyster Bay	1-80000	3, 4. T. Wasserbach.
207	1334	Matagorda Bay	1-80000	3, 4. T. Wasserbach.
208	1849	Pass Cavallo, Lavaca, and San Antonio Bays	1-80000	3, 4. T. Wasserbach.
337	1970	Boston Harbor	1-40000	1. H. L. Thompson. 2, 3. W. A. Thompson. 4. E. H. Sipe and H. T. Knight.
369	1987	New York Bay and Harbor, upper sheet	1-40000	1, 2. R. F. Bartle.
369	1988	New York Bay and Harbor, lower sheet	1-40000	1, 2. R. F. Bartle.
420	1994	Beaufort Harbor	1-40000	3, 4. T. Wasserbach.
447	1155	St. Simon's Sound, Brunswick Harbor, and Turtle River	1-40000	4. H. L. Thompson.
675	1980	Point Pinos to Bodega Head	1-200000	1, 2. W. A. Thompson. 4. E. H. Sipe.
		SKETCHES AND ILLUSTRATIONS COMMENCED.		
	1965	Index Map No. 8, Subsketch No. 29		1, 4. H. T. Knight.
		NEW CHARTS CONTINUED.		
16	1855	Key West to Tampa Bay	1-400000	3. H. C. Evans.
17	1803	Tampa Bay to Cape San Blas	1-400000	3. H. C. Evans. 4. A. Petersen.
31	1942	Nantucket Shoals to New York, western sheet	1-200000	1. J. G. Thompson. 4. James P. Cox and R. F. Bartle, jr.

Engraved plates of charts completed, continued, or commenced, etc.—Continued.

Catalogue No.	Plate No	Title.	Scale.	Engravers and work.
		NEW CHARTS CONTINUED—continued.		
101	1937	Eastport to Little River	1-80000	3. W. A. Thompson. 4. J. G. Thompson.
101	1955	Eastport to Little River, offshore	1-80000	3. W. A. Thompson. 4. J. G. Thompson.
102	1742	Little River to Petit Manan	1-80000	4. E. A. Maedel.
102	1860	Little River to Petit Manan, offshore	1-80000	4. J. G. Thompson.
119	1927	Great South Bay, Fire Island	1-80000	3. H. C. Evans. 4. E. H. Sipe and H. T. Knight.
126	1935	Delaware Bay and River, Reedy Point to Trenton	1-80000	1, 2. Joseph Enthoffer. 4. A. Petersen.
147	1861	Cove Sound to Bogue Inlet, including Cape Lookout	1-80000	4. E. A. Maedel.
151	1695	Little River Inlet and part of Long Bay	1-80000	3. R. F. Bartle.
178	1931	Hog Island to Wall Creek, including Anclote Anchorage	1-80000	3. H. C. Evans. 4. A. Petersen, J. C. Entwistle, and H. L. Thompson.
179	1932	Wall Creek to Cedar Keys	1-80000	1, 2. R. F. Bartle. 4. A. Petersen, J. C. Entwistle, and H. T. Knight.
187	1284	Pensacola Bay to Mobile Bay	1-80000	3. R. F. Bartle. 4. R. F. Bartle, jr.
304	1938	Cross Island to Nash Island	1-40000	1, 2. Joseph Enthoffer.
401D	1664	James River, No. 4, City Point to Kingland Creek	1-20000	4. H. L. Thompson.
401E	1679	James River, No. 5, Kingland Creek to Richmond	1-20000	4. H. L. Thompson.
600[1]	1755	San Diego Point to Point Arena	1-1200000	2. W. A. Thompson. 4. J. G. Thompson, H. T. Knight, and R. F. Bartle, jr.
600[2]	1908	San Francisco to the Straits of Juan De Fuca	1-1200000	1. H. T. Knight. 4. J. G. Thompson and H. T. Knight.
669	1828	San Luis Obispo Bay and Approaches	1-20000	3. T. Wasserbach. 4. Ludwig Von Logau.

REPORT OF THE DRAWING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR ENDING JUNE 30, 1888.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, July 1, 1888.

DEAR SIR: During the fiscal year 1887-'88 the Drawing Division has remained in my charge.

For the first nine months of the year the number of draughtsmen remained the same as the year preceding. During the last three months under the deficiency appropriation five additional draughtsmen were employed.

The assignment of work has been about the same as the preceding year, as follows:

A. Lindenkohl was mostly employed upon hydrographic reductions, corrections of and additions to published charts, progress sketches for the Annual Report, and answering various calls for information. He has rendered valuable service, at times, by directing the work of the Division during the absence of its Chief.

H. Lindenkohl was mostly engaged upon finished drawings for photolithographing, and all kinds of work requiring dispatch. He has also done the usual amount of lithographing for the Annual Report. During the year he has done an unusually large amount of valuable work.

E. H. Fowler has made reductions for engraving and photolithographing, projections, and verifications.

E. J. Sommer has made reductions for engraving and photolithographing, projections, and verifications.

P. Erichsen has been mostly engaged upon inking topographical sheets and measuring areas of engraved work.

E. Molkow has worked upon reductions for harbor charts for engraving, inked topographical sheets, made projections, and measured areas of engraved work and topographical surveys.

C. Mahon has been employed principally upon hydrographic reductions and lettering plane-table sheets.

E. A. Trescot has made drawings of charts and diagrams for photolithographing, and registered for the Division the original topographical and hydrographic charts. At times he has performed the clerical duties of the Division.

J. Olberg has made the usual copies of field sketches.

W. H. Benton has been mostly engaged upon drawings of charts for photolithographing.

H. J. Schneider has made miscellaneous tracings, especially those to answer calls by private parties for copies of original surveys.

During nearly three months of the latter part of the year W. Baumann, G. F. Kroll, F. J. del Corrall, and G. Wedekind were engaged as temporary draughtsmen; W. Baumann upon a chart for photolithographing, and the others upon miscellaneous work and tracings.

C. G. Bouis was attached to the Division about two weeks on trial.

J. H. Roeth performed the clerical work of the Division until January 9, 1888, when he was transferred to the office of the Hydrographic Inspector.

From January 16 to May 16 Assistant W. I. Vinal was attached to the Division, and rendered efficient service by registering several thousands of miscellaneous maps and drawings, which had accumulated in about forty years.

In addition to the list of charts submitted, which comprises all the regular publications, for which the drawings have been advanced or completed, there have been prepared, at the request of the United States attorney for the District of Columbia, careful tracings of the "Dermott Map" and of the "King Plats" of the city of Washington for the purpose of being photolithographed.

I desire to say that the number of skilled draughtsmen in the Division is inadequate to the demand made upon it for all purposes. We want more of the best, for the best are always to be preferred from the standpoint of economy.

Special effort has been made to put the results of the most recent surveys promptly before the public, and we have succeeded, with the co-operation of the Engraving Division and by photolithography, in mapping the important resurveys in Delaware Bay, New York Harbor, and East River in shorter intervals from the time of the resurveys than ever before accomplished by the Office.

Special attention has been given to such parts of the coast as were inadequately supplied with charts, notably the west coast of Florida and the coasts of Oregon and of Washington Territory. A number of charts, local and general, of these sections were commenced or issued, and efforts are still continued in this direction, so that it is hoped that at no distant day all parts of the coast will be provided with charts.

The gratifying reception by the public which our full-scale photolithographed charts have had during the past year, encourages our best efforts in that direction. The chart which gives the most information will be in most demand for local purposes.

Respectfully, yours,

E. HERGESHEIMER,
Assistant Coast and Geodetic Survey,
In charge of Drawing Division.

Mr. B. A. COLONNA,
Assistant in charge of Office.

DRAWING DIVISION.

Charts completed or in progress during the year ending June 30, 1888.

1. Topography. 2. Hydrography.

Nos. of charts.	Titles of charts.	Scale.	Draughtsman.	Remarks.
	SAILING CHARTS.			
A	Cape Sable to Cape Hatteras	1-1200000	2. A. Lindenkohl	Corrections and additions.
B	Cape Hatteras to Key West	1-1200000	2. A. Lindenkohl	Do.
D	Gulf of Mexico and Straits of Florida	1-2100000	2. A. Lindenkohl; 1, 2. E. J. Sommer.	Do.
600[1]	San Diego to Point Arena	1-1200000	1, 2. A. Lindenkohl; 1. H. Lindenkohl.	In progress.
603	Umpquah River to the N. W. boundary	1-1200000	1. A. Lindenkohl	Do.
	GENERAL CHARTS OF THE COAST.			
6b	Western part Isle au Haut to Cape Cod	1-400000	1, 2. E. J. Sommer	Corrections.
7	Cape Ann to Gay Head	1-400000	2. A. Lindenkohl	Corrections and additions.
8a	Approaches to New York—Block Island to Cape May.	1-400000	1, 2. H. Lindenkohl	Corrections.
10	Cape Henry to Cape Lookout	1-400000	2. A. Lindenkohl	Corrections and additions.
11	Cape Hatteras to Cape Romain	1-400000	1, 2. A. Lindenkohl	Do.
12	Cape Romain to St. Mary's Entrance	1-400000	2. A. Lindenkohl	Corrections.
15	Straits of Florida	1-400000	1. P. Erichsen and E. H. Fowler	Additions.
16	Key West to Tampa Bay	1-400000	2. A. Lindenkohl and E. H. Fowler	
17	Tampa Bay to Cape San Blas	1-400000	2. A. Lindenkohl	Finished.
20	Atchafalaya Bay to Galveston	1-400000	1. P. Erichsen	In progress.
671	San Diego to Santa Monica	1-200000	1. E. H. Fowler	Do.
675	Point Pinos to Bodega Head	1-200000	1. H. Lindenkohl, E. H. Trescot, E. H. Fowler, and F. J. Corral.	
677	Point Arena to Cape Mendocino	1-200000	1, 2. A. Lindenkohl; 2. E. J. Sommer.	Corrections.
681a	Approaches to the Columbia River	1-200000	2. E. A. Trescot	In progress.
684	Sea-coast and interior harbors of Washington Territory, from Gray's Harbor to Olympia, including Washington Sound.	1-300000	1, 2. A. and H. Lindenkohl.	Photolithograph, corrections.
	COAST AND HARBOR CHARTS.			
101			1, 2. A. Lindenkohl	In progress.
302a	Eastport Harbor	1-40000	1. E. H. Fowler; 2. H. Lindenkohl	Corrections.
102			2. E. J. Sommer; 1, 2. E. H. Fowler	In progress.
303	Moose Cove to Englishman's Bay	1-40000	2. A. Lindenkohl; 1. C. Mahon	Do.
304	Cross Island to Nash Island	1-40000	2. A. Lindenkohl; 1, 2. E. H. Fowler.	Finished.
305	Nash Island to Schoodic Island	1-40000	2. A. Lindenkohl	Corrections.
104	Penobscot Bay	1-80000	2. A. Lindenkohl	Do.
313	Damariscotta and Medomak Rivers	1-40000	2. A. Lindenkohl	Do.
106	Kennebec Entrance to Saco River	1-80000	2. H Lindenkohl	Do.
315	Casco Bay	1-40000	1, 2. H. Lindenkohl	Do.
325	Portland Harbor	1-20000	1, 2. A. Lindenkohl and H. Lindenkohl.	Do.
108	Wells to Cape Ann	1-80000	2. A. Lindenkohl	Do.
337	Boston Harbor	1-40000	2. C. Mahon	Do.
111	Eastern Sheet—Monomoy and Nantucket Shoals to Muskeget Channel.	1-80000	1, 2. H. Lindenkohl and C. Mahon	Do.
112	Middle Sheet—Muskeget Channel to Buzzard's Bay and entrance to Vineyard Sound.	1-80000	1. E. H. Fowler	Do.
113	Western Sheet—Cuttyhunk to Block Island, including Narragansett Bay.	1-80000	1, 2. A. Lindenkohl; 2. H. Lindenkohl.	Do.
346	Edgartown Harbor	1-20000	2. A. Lindenkohl	Do.
353	Narragansett Bay	1-40000	2. H. Lindenkohl	Do.
353[2]	Newport Harbor and entrance	1-20000	1, 2. H. Lindenkohl	Photolithograph, corrections.
354	Bristol Harbor	1-20000	2. E. J. Sommer	Corrections.
115	Long Island Sound, Middle Sheet—Plum Island to Welch's Point.	1-80000	2. A. Lindenkohl; 1. E. H. Fowler	New edition.
116	Western Sheet—Welch's Point to New York	1-80000	1, 2. E. H. Fowler	In progress.

Charts completed or in progress during the year ending June 30, 1888—Continued.

Nos. of charts.	Titles of charts.	Scale.	Draughtsman.	Remarks
	COAST AND HARBOR CHARTS—Continued.			
358	Fisher's Island Sound	1-40000	1, 2. H. Lindenkohl	Photolithograph, corrections.
361²	Harbors of Branford, Sachem's Head, etc	1-10000	1, 2. H. Lindenkohl	Photolithograph completed.
361³	Entrance to Norwalk and Saugatuck	1-10000	2. H. Lindenkohl	Do.
361⁴	Port Jefferson	1-10000	1, 2. E. A. Trescot	Photolithograph.
366	Hempstead Harbor	1-20000	2. A. Lindenkohl	Corrections.
361⁵	Long Island Sound, between Throg's Neck and New Rochelle.	1-10000	1, 2. H. Lindenkohl	Photolithograph completed.
367	Oyster or Syosset Harbor	1-30000	1, 2. E. Molkow	New edition.
368	Huntington Bay	1-30000	1, 2. E. Molkow	Do.
369	New York Bay and Harbor	1-40000	2. A. Lindenkohl; 1, 2. H. Lindenkohl; 1. P. Erichsen and E. J. Sommer.	Corrections.
369⁶	East River, Lawrence Point to Throg's Neck	1-10000	1, 2. H. Lindenkokl	Photolithograph, completed.
369⁸	Hudson River, Fifty-third street to Fort Washington	1-10000	1, 2. H. Lindenkohl; 2. A. Lindenkohl.	Do.
370	No. 1, New York to Haverstraw	1-60000	P. Erichsen	Corrections.
121	Sandy Hook to Barnegat Inlet	1-80000	1. A. Lindenkohl	Do.
123	Absecon Inlet to Cape May	1-80000	1. H. Lindenkohl; 2. C. Mahon	Do.
124	Lower Sheet—Delaware Entrance	1-80000	1. A. Lindenkohl; 2. E. J. Sommer.	
125	Middle Sheet—Part of Delaware Bay and River	1-80000	1, 2. E. J. Sommer; 1. C. Mahon	New edition, completed.
126	Upper Sheet—Delaware River, Port Penn to Trenton.	1-80000	2. A. Lindenkohl; 1, 2. H. Lindenkohl.	New—in progress.
127	Cape May to Isle of Wight	1-80000	2. E. J. Sommer and C. Mahon	Corrections and additions.
128	Isle of Wight to Chincoteague Inlet	1-80000	2. E. J. Sommer	Additions.
129	Chincoteague Inlet to Hog Island Light	1-80000	1. P. Erichsen; 2. E. J. Sommer	Additions and corrections.
131	No. 1, Entrance to Chesapeake Bay, Hampton Roads, etc.	1-80000	2. A. Lindenkohl and E. J. Sommer; 1. E. A. Trescot.	
132	No. 2, York River to Pocomoke Sound	1-80000	1. E. A. Trescot	Corrections.
134	No. 1, Potomac River to Choptank River	1-80000	1. 2. A. Lindenkohl	Do.
135	No. 2, Choptank River to Magothy River	1-80000	2. H. Lindenkohl	Do.
136	No. 3, Magothy River to Head of Bay	1-80000	2. A. and H. Lindenkohl; 1, 2. E. J. Sommer.	Do.
384	Patapsco River and Baltimore Harbor	1-60000	1. P. Erichsen; 2. E. J. Sommer	Do.
401*a*	James River, No. 1. Hampton Roads to Point of Shoals.	1-40000	1. C. Mahon	Do.
404*b*	Norfolk Harbor	1-10000	1. A. Lindenkohl	Do.
141	Albemarle Sound, Western Sheet—Pasquotank River to Roanoke and Chowan Rivers.	1-80000	2. A. Lindenkohl	Do.
420	Beaufort Harbor	1-40000	1, 2. C. Mahon	Do.
147	Cape Lookout to Bogue Inlet		2. C. Mahon	Do.
150	Masonboro Inlet to Shallotte Inlet, including Cape Fear.	1-80000	1, 2. A. Lindenkohl and C. Mahon; 1. H. Lindenkohl and E. H. Fowler; 2. E. J. Sommer.	Do.
424	Cape Fear River Entrance	1-30000	1, 2. A. Lindenkohl; 2. H. Lindenkohl.	Do.
425	Cape Fear River, from Federal Point to Wilmington	1-30000	1, 2. A. Lindenkohl; 2. E. A. Trescot and E. J. Sommers.	Do.
153	North Island to Long Island, including Cape Romain.	1-80000	2. C. Mahon	
428	Winyah Bay	1-40000	1, 2. H. Lindenkohl	Photolithograph corrections.
156	Savannah to Sapelo Island	1-80000	2. A. Lindenkohl	Corrections.
447	St. Simon's Sound Brunswick Harbor and Turtle River	1-40000	2. A. Lindenkohl	Do.
167	Elbow Key to Matecumbe Key	1-80000	2. C. Mahon	Do.
460	Key West Harbor	1-50000	1. A. Lindenkohl	Do.
175	San Carlos Bay to Lemon Bay, including Charlotte Harbor.	1-80000	1. E. A. Trescot	Additions.
178	Hog Island to Wall's Creek	1-80000	2. A. Lindenkohl	Finished.
179	Wall's Creek to Cedar Keys	1-80000	2. A. Lindenkohl; 1. E. J. Sommer; 2. C. Mahon.	Do.

Charts completed or in progress during the year ending June 30, 1888—Continued.

Nos. of charts.	Titles of charts.	Scale.	Draughtsman.	Remarks.
	COAST AND HARBOR CHARTS—continued.			
480	Cedar Keys	1-50000	2. A. Lindenkohl	Finished.
180	Cedar Keys to Deadman's Bay	1-80000	2. C. Mahon	Do.
187	Pensacola Bay to Mobile Bay	1-80000	1. A. and H. Lindenkohl	Do.
191	Lake Borgne and Pontchartrain	1-80000	1, 2. A. Lindenkohl	Do.
503	The Rigolets	1-20000	1, 2. A. Lindenkohl. 2. P. Erichsen and C. Mahon.	Do.
516	Atchafalaya Bay	1-50000	2. A. Lindenkohl	Do.
204	Galveston Bay	1-80000	2. A. Lindenkohl	Do.
520	Galveston Entrance	1-40000	1, 2. A. and H. Lindenkohl	Do.
206	Oyster Bay to Matagorda Bay	1-80000	1, 2. A. Lindenkohl	Do.
	Brazos River		1, 2. A. Lindenkohl	Do.
208	Pass Cavallo, Lavaca and San Antonio Bays	1-80000	1, 2. A. Lindenkohl	Do.
209	Aransas Pass, Aransas and Copano Bays	1-80000	2. A. Lindenkohl	Do.
211	Padre Island, latitude 27° 12′ to latitude 26° 33′	1-80000	2. C. Mahon and H. Lindenkohl	Do.
606	San Diego Bay	1-40000	1. H. Lindenkohl and P. Erichsen	
609	San Juan Capistrano	1-10000	1, 2. W. H. Benton	Photolithograph completed.
610	Wilmington and San Pedro Harbor	1-40000	2. H. Lindenkohl. 1, 2. E. J. Sommer.	Photolithograph corrections.
611	Santa Barbara	1-20000	1, 2. E. J. Sommer	Do.
618	Monterey Bay	1-60000	1. E. J. Sommer	Corrections.
619	Santa Cruz and Ana Nuevo Harbors	1-40000	1. E. J. Sommer.	Do.
624	Petaluma and Napa Creeks	1-30000	2. E. J. Sommer	Do.
629	Drake's Bay	1-40000	1, 2. A. Lindenkohl and C. Mahon	Do.
693	Eel River Entrance	1-20000	1, 2. W. H. Benton	Photolithograph finished.
634	Cape Orford and Reef	1-40000	1, 2. H. Lindenkohl. 1. E. A. Trescot.	Corrections.
636	Coquille River Entrance	1-10000	1. E. A. Trescot	Photolithograph.
637	Coos Bay	1-20000	1. E. A. Trescot	Corrections
638	Umpquah River Entrance	1-20000	1. H. Lindenkohl and E. A. Trescot. 1, 2. W. H. Benton.	Photolithograph finished.
639	Sinslaw River Entrance	1-10000	2. H. Lindenkohl	Do.
664	Yaquina River Entrance	1-20000	1. E. A. Trescot	Corrections.
660	Nestuggah Bay and River	1-10000	1, 2. W. H. Benton	Photolithograph..
659	Tillamook Bay	1-20000	1. E. A. Trescot	Corrections.
640	Columbia River No. 1, from entrance to Upper Astoria.	1-40000	1. E. J. Sommer. 1, 2. E. H. Fowler. 2. H. Lindenkohl.	Do.
641	No. 2, Upper Astoria to Tenasillihee Island	1-40000	1. E. J. Sommer	Additions and corrections.
641b	No. 4, Grim's Island to Kalama	1-40000	2. H. Lindenkohl	Corrections.
643a	Destruction Island	1-40000	1. E. A. Trescot	Do.
645	Cape Flattery and Nee-ah Harbors	1-40000	1. A. Lindenkohl. 1, 2. H. Lindenkohl.	Corrections and additions.
685	Admiralty Inlet	1-80000	1, 2. A. Lindenkohl and C. Mahon	Completed.
690	Commencement Bay and city of Takoma	1-20000	1. H. Lindenkohl	New edition.
686	Puget Sound	1-80000	1. A. and H. Lindenkohl	Commenced.
705	Frederick Sound, Southeast Alaska	1-200000	1, 2. W. Baumann	Photolithograph completed.
766	Kachekmak Bay, Cook's Inlet	1-128060	1. H. Lindenkohl	Corrections.
960	Alaska and adjoining territory	1-3000000	1, 2. A. and H. Lindenkohl	Photolithograph.

REPORT OF THE CHART DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE FISCAL YEAR ENDING JUNE 30, 1888.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, July 1, 1888.

SIR: I have the honor to submit the following report of the Chart Division for the year ending June 30, 1888:

The custody, correction, and issuing of charts was made a Division on the 15th of December, 1887, and I received instructions to take charge; previously this had been a part of the Miscellaneous Division.

As now organized the duties are: To receive all charts from whatever source; to give notice when a new supply is required; stamp the catalogue number and date of printing on each; color the buoys, lights, and sectors; correct and verify them up to the date of issue from the Division, marking that date upon them; to fill all orders for charts, and to keep a book account of the numbers received and issued.

The total number of charts disposed of during the past year is 44,595, being an increase of .285 per cent. on the issue of the previous year. This is in part due to the number of new charts added to the catalogue, of which there were nine from plate-printing and eleven photolithograph charts. Allowing for these the per cent. increase is about .26. Averaging the total number of charts issued with the full number in the catalogue, shows that about one hundred and thirteen of each were disposed of the past year, against eighty-nine and four-tenths for the year before.

Of the assistants in the Division, Mr. H. G. Eichholtz has had general charge of the Chart Room. Mr. J. H. Barker, with the verification and correction of charts, has Mr. Archie Upperman as his assistant.

The fact that during the past six months some three thousand one hundred and nine corrected charts have been sent to the Hydrographic Office of the Navy, where they are subjected to a most critical examination, and that in no case has a single error or oversight been found for which this Division is at fault, tells strongly of the painstaking care of both Messrs. Barker and Upperman.

Mr. J. L. Smith has been employed in stamping the catalogue number, etc., on the charts, printing slips, etc.

Miss L. A. Mapes has had charge of the books, and when not engaged on them has been employed in coloring buoys, correcting catalogues, etc.

Miss Mary Thomas has been engaged in coloring buoys, lights. Miss Sophie Hein in chart and catalogue corrections, and in coloring light-sectors. Mrs. Jennie H. Fitch commenced work on the 4th April coloring buoys and lights, and has also made ready for mailing some four thousand copies of Appendix 12 of 1886, and letters accompanying, and has also nearly completed an alphabetical list of the parties to whom they were sent.

Miss May Thomas was engaged in correcting catalogues.

Mrs. A. E. White was in this Division about eight days (in May), and Miss Lizzie Robinson from May 19 to June 30, both employed on catalogue corrections.

I have much pleasure in saying that all the employés in the Division, by their energetic attention to their duties, are deserving of special commendation.

Respectfully, yours,

W. H. DENNIS,
Assistant U. S. Coast and Geodetic Survey,
In charge of Chart Division.

B. A. COLONNA, Esq.,
Assistant in charge of Office and Topography.

New charts added to catalogue, from July 1, 1887, to June 30, 1888.

Title.	Date.	Catalogue No.
FROM ENGRAVED PLATES.	1887.	
Jupiter Inlet to Hillsboro' Inlet	July 14	164
From latitude 27° 40' southward to Jupiter Inlet	July 28	163
Masonboro' Inlet to Shallotte Inlet	Feb. 13	150
Lemon Bay to Tampa Bay	Feb. 13	176
Point Arena to Cape Mendocino	Apr. 12	677
Commencement Bay to Tacoma City	Apr. 12	690
Columbia River, Kalama to Fales Landing	May 25	641c
Columbia River, Fales Landing to Portland	May 25	641d
St. John's River, Tocoi to San Mateo	May 28	455d
PHOTO-LITHOGRAPHS.		
Plan of City of Washington	July 14	3035a
Siuslaw River entrance	July 30	639
Sumner Strait and northern part Clarence Strait	Oct. 7	706
Block Island	Nov. 9	356
Eastern part Long Island Sound	Nov. 15	114a
From Quoddy Roads to Head Harbor Islands	Nov. 19	101a
Harbors of Brandford, Sachem's Head, and the Thimbles	Jan. 17	361^2
Port Jefferson, Long Island Sound	May 29	361^4
Entrance to Norwalk and Saugatuck Rivers and Norwalk Islands	June 6	361^3
Hudson River from Fifty-third Street to Fort Washington	June 15	369^8
East River, Lawrence Pt. to Throg's Neck	June 15	369^6

Report of charts issued for the year ending June 30, 1888.

	July 1 to December 31.		January 1 to June 30.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.
Sales agents	12,194	$5,024.80	13,079	$5,651.45	25,273	$10,676.25
Sales by Office and Chart Division	304	119.50	338	143.75	642	263.25
Congressional account	1,117	508.90	1,366	630.60	2,483	1,139.50
Hydrographic office, Navy	1,398	543.55	3,109	1,180.90	4,507	1,724.45
Light-house Board	805	302.20	982	417.45	1,787	719.65
Executive Departments	2,836	1,178.31	2,478	921.85	5,314	2,100.16
Foreign Governments	297	124.70	820	270.00	1,117	394.70
Miscellaneous	83	36.55	116	49.45	199	86.00
Totals:						
Number issued	19,034	$7,838.51	22,288	$9,265.45	41,322	$17,103.96
Number condemned	2,881	1,155.43	387	146.35	3,268	1,301.78

Charts on hand and received from July 1, 1887, to June 30, 1888.

	Number.	Value.	Number.	Value.
On hand July 1, 1887	39,391	$12,347.01		
Received July 1 to December 31, 1887	20,503	8,018.15		
Charts returned	2,115	773.29		
Total on hand and received to December 31, 1887			62,009	$21,138.45
Issued July 1 to December 31	19,034	7,838.51		
Condemned to December 31	2,881	1,155.43		
Total issued (including number condemned)			21,915	8,993.94
On hand by books January 1, 1888			40,094	12,144.51
To difference between books and inventory			1,976	20.84
On hand by inventory January 1, 1888			38,118	12,165.35
Received January 1 to June 30 (plate)	16,025	7,103.85		
Received January 1 to June 30 (stone)	5,160	2,150.00		
Section maps, D. C	1,977	197.70		
Returned charts	477	276.20		
			23,639	9,727.75
Total on hand and received June 30, 1888			61,757	$21,893.10
Issued January 1 to June 30	22,288	$9,265.45		
Condemned to June 30	387	146.35		
Total issued to June 30 (including number condemned)			22,675	9,411.80
On hand by book and inventory July 1, 1888			39,082	12,481.30

REPORT OF THE INSTRUMENT DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR ENDING JUNE 30, 1888.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, August 22, 1888.

DEAR SIR: I have the honor to submit the following report of the Instrument Division for the fiscal year ending June 30, 1888:

During the year no change has been made in the personnel of the Division, excepting that caused by the resignation of Mr. W. Suess, December 31, 1887, and the employment in his place of Mr. O. Storm. The latter entered upon his duties January 14, 1888.

The equipment of the instrument shop has been further improved by the addition of sundry minor tools and a new lathe, of large size; and that of the carpenter shop by the addition of a new improved lathe, also of large size. As was anticipated, the betterment of the shop equipment has resulted in an improvement both in the quality and quantity of the work produced, and I take pleasure in reporting that we are now in a condition to turn out new instruments of the highest grade. Several first-class instruments, which will be noticed further on, have already been made, and others are now on hand.

A number of old instruments have been entirely or partially reconstructed, and the usual large amount of repairs and alterations of field instruments has been attended to.

The large and increasing amount of repairing constantly required, necessarily limits the production of new work, and I shall therefore recommend that in future two additional mechanicians be estimated for. This increase of force will be necessary from the fact that many of our older instruments are becoming worn and unfit for use and will have to be replaced by new ones, which our present small force will be unable to supply with sufficient rapidity. A new theodolite, for example, of the sizes and pattern recently approved, will occupy a good mechanician for at least four months, and when he is frequently compelled to lay aside his work temporarily, as is now the case, to attend to repairs, etc., more urgently needed, it is obvious that the work of renewing our stock of instruments will be a slow one, and that a considerably larger force could, for a time at least, be advantageously employed.

The following is a list of new instruments made or partly made during the year, and of old ones reconstructed: Six three-armed protractors, two thirty-seven-inch astronomical transits, two geodesic micrometer levels, two sounding registers, thirty specimen cups, twelve plane table alidades (reconstructed), two theodolite magnetometers (reconstructed and enlarged), three micrometers, two large Steinheil heliotropes, sundry metric scales, etc., etc.

The above were all completed within the limits of the fiscal year excepting the heliotropes and alidades; the former, however, were completed by July 10, but the latter, owing to numerous interruptions caused by urgent repairing work, will not be finished until the latter part of August.

The two new transits are of the most approved pattern; have all the modern improvements, and are, in short, first-class instruments. Each has a telescope of focal length 37 inches, clear aperture of 3 inches, and magnifying powers from 37 to 108. The pivots are cylindrical and made of bell-metal, the Ys being of "half-hard" brass. Agate bearings have been discarded, and the azimuth and level adjustments are made at the base instead of at the axis; this maintains a constant relation between the Ys and pivots, and gives a more perfect bearing surface. The inclined surfaces of the Ys are true planes instead of curved surfaces, and the cylindrical pivots consequently bear throughout their length instead of at single points as in the older instruments.

The final turning of the pivots was made by Mr. E. G. Fischer, who succeeded in bringing their inequality within one-tenth of a division of the level, a division (2 ^{mm}) of level having a value of 1″.2.

These instruments are now in use by the longitude parties, and it is confidently expected that after a thorough trial they will be found superior to any of the transits heretofore used by the Survey.

The two new Geodesic Levels are of the same pattern as Level No. 1, the instrument used on the transcontinental line of levels from Sandy Hook to St. Louis. One of these instruments is now at the Cincinnati Exposition, and the other will shortly be used on the line of levels from Washington to Annapolis.

The twelve alidades, although marked in the list as "reconstructed," are practically new instruments, as all the parts excepting the telescope tubes have been renewed. The other new instruments in the list do not call for special mention.

Working drawings and patterns are now being made for six new 8-inch Repeating Theodolites, three of which will be adapted for latitude and azimuth work; six new Geodesic Leveling Rods have also been commenced, and the construction of twenty-four Three-armed Protractors will shortly be begun.

During the year Mr. E. G. Fischer has performed the duties of Chief Mechanician, and has had immediate supervision of the details of the work in the instrument shop. To his ability, skill, and zeal the satisfactory results are in a large measure due, and I take this occasion to express my high appreciation of the value of his services, and to thank him for his hearty co-operation in the efforts to increase the efficiency of the Division.

Mr. H. O. French has, as heretofore, had immediate charge of the work of the carpenter shop, and has performed his duties in his usual efficient and thorough manner.

The miscellaneous duties of the Division, including the care of the instruments, camp-equipage, and general property, the receipts and shipments of the same, the examination and adjustment of instruments, and determination of instrumental constants, the purchase of new instruments and supplies, the official correspondence, and the keeping of the records and inventories have likewise received due attention.

The following statement shows in detail the force employed during the year and the character of the work performed by each:

Mr. E. G. Fischer, Chief Mechanician, has made such graduations as were required of theodolites, sextants, protractors, alidade arcs, and transit circles, and has made the working drawings for the use of the pattern-makers and mechanicians.

Mr. E. Eshleman served during the entire year, and was employed upon the adjustment of instruments and the repairs of theodolites, levels, zenith telescopes, ship alidades, sextants, plane-tables, station transits, heliotropes, dip circles, magnetometers, pantographs, protractors, engineers' transits, gradienters, chronographs, meridian telescopes, etc. He has also attended to the ruling of diaphragms, the silvering of sextant and heliotrope mirrors, etc.

Mr. L. A. Fischer served during the whole year, and was employed upon new protractors, sounding registers, P. T. alidades, astronomical transits, and letter gauges and upon miscellaneous repairs of protractors, base bar comparators, and zenith telescopes. He has also made new stepping wheels for the dividing engine and assisted in miscellaneous work for the Weights and Measures Division.

Mr. P. Vierbuchen served during the whole year, and was employed upon miscellaneous repairs of theodolites, plane tables, alidades, tide gauges, protractors, levels, reconnoitering telescopes, level rods, vertical circles, engineers' transits, zenith telescopes, sectors, chronographs, signal lamps, heliotropes, sextants, odometers, surveyors' compasses, binoculars, etc.

Mr. T. Gerhard served during the year, and was employed upon new godesic levels, alidades, and micrometers, and upon reconstruction of magnetometer and repairs of theodolites, gradienters, meridian telescopes, and zenith telescopes. He also assisted in miscellaneous work for Weights and Measures Division.

Mr. S. Kearney served during the whole year, and was employed upon miscellaneous repairs of plane tables, station transits, engineers' transits, beam compasses, leveling rods, steel tapes, etc., and assisted in the work on the new levels, transits, and alidades. He also made miscellaneous tools and attended to the gas-engine.

Mr. W. Suess served during the first half of the year, and was employed upon repairs of sextants, magnetic instruments, protractors, binoculars, proportional dividers, compasses, etc. He also attended to the office batteries and bells, repaired the ruling-machine, ruled sundry metric scales, and did some work on the level-grinder.

Mr. O. Storm served from January 16 to the close of the fiscal year, and was employed upon the two new transits, the new alidades and heliotropes, and in making sundry chocks and tools.

Mr. M. Lauxman served during the whole year, and was employed upon miscellaneous repairs, making tools, and taps, and dies, etc. He also assisted in the work on the new transits, alidades, and specimen cups.

Mr. H. O. French, assisted by Messrs. G. W. Clarvoe and C. N. Darnall, has attended to the work of the carpenter shop, including the making of patterns, stands, racks, trays for the Photograph Division, instrument cases and boxes, book and chart cases, signal lamp boxes, etc., the packing for transportation, and miscellaneous repairs to building and office furniture.

Mr. R. C. Glascock served during the year as property clerk, and has attended to the books and records concerning the general property of the Survey, and the official correspondence relating thereto. He has also compiled the monthly reports of the Division.

Yours respectfully,

ANDREW BRAID,
Assistant Coast and Geodetic Survey,
In charge of Instrument Division.

Mr. B. A. COLONNA,
Assistant in charge of Office.

REPORT OF THE TIDAL DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR ENDING JUNE 30, 1888.

TIDAL DIVISION U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, D. C., June 30, 1888.

SIR: I have the honor to submit herewith the report of this Division for the fiscal year ending June 30, 1888.

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

1. An aggregate of five years, eight months of record from automatic tide-gauges, five years nine months of tabulated high and low waters and half-hourly ordinates from the same gauges, two years one month of meteorological observations, one year of observed temperatures and densities of the sea; one hundred and fourteen original and one hundred and eight duplicate volumes of observations on staff and box gauges have been received, examined, and registered, and one hundred and thirty letters prepared relating thereto.

2. The proofs of the tide-tables for the Pacific Coast for the year 1888, one volume octavo, have been read and differenced. The like tables for both the Atlantic and Pacific Coasts for the year 1889, two volumes octavo, have been prepared, read, and twice differenced in proof.

3. An aggregate of one hundred and one tide-notes has been furnished for publication on thirty-eight charts, and thirty-one tide-notes have been prepared in response to three requisitions from the Coast Pilot Division.

4. For use by field parties, seventy-five descriptions of tidal bench-marks, with heights above the plane of reference, etc., have been furnished in response to twenty-three requisitions.

5. Tidal data and information have been prepared and furnished in reply to twenty-six calls from persons not connected with the Survey.

6. A careful and laborious determination of mean half-tide level at Sandy Hook, N. J., from the two series, January 1, 1882, to August 31, 1884, and December 1, 1886, to April 1, 1888, has been made.

7. An investigation has been made into the correct mean establishments and ranges at San Francisco, Cal., and Astoria, Oregon. That at Astoria has been completed and the results incorporated in the tide tables for 1889.

8. The harmonic reductions for New London, Conn., Washington, D. C., and Key West, Fla., begun last year, have been finished, the work required aggregating about the same as the reduction of one year of observations. A very full reduction, including a harmonic reduction, of one year's observations at St. Paul, Kadiak Island, Alaska, has been about two-thirds completed. Upon this reduction will be based predictions for Kadiak Island for 1890 as an additional principal station on our western coast.

9. Non-harmonic reductions have been made of short series at one hundred and thirty-four stations, aggregating about ten years of continuous observations. This includes stations on various parts of the Atlantic and Pacific coasts. About half of them are on the coast of Maine, where the work has been begun of reducing all tidal observations on the Atlantic coast and making a complete showing of results in form to be immediately available.

The character of the tidal work is such, and such are the circumstances of its performance, that a detailed statement of the work done by each clerk during the year would be too voluminous an affair to be of much value, and would require for its production a constant and serious diversion of our attention from tides to statistics. In the preparation of tide notes, descriptions of bench-marks with a statement of their relation to the plane of reference, and other tidal data, in response to requisitions, the rule is to produce the data as promptly as is practicable. To this end several clerks will be employed upon the same requisition; for example, one making a thorough search and bringing together all available data and revising results, one or two reducing observations, another making the necessary copies of sketches and verbal descriptions, etc. Nor do the exigencies of the work admit of our always adhering to a fixed order of procedure, or invariably distributing the same part of the work to the same clerk. And like remarks apply with more or less force to every description of the work of this Division. An attempt has been made in the daily reports, rendered monthly, to afford means for judging of the efficiency of the individual clerks by a statement of the class of work upon which each was employed, and, since there is no means of measuring its quantity and stating it in units, a description by station and date has there been given, by means of which it may be found and subjected to the inspection of an expert. To those reports I beg leave to refer for detailed and more specific statement.

The following is a statement of the general character of the work of each clerk:

Mr. L. P. Shidy has been engaged upon almost every description of our work, upon the higher parts of the harmonic reductions, the non-harmonic reductions, their comparison and revision, the preparation of tide notes and other tidal data, the differencing of the tide tables, reading of proof, etc. I depend largely upon Mr. Shidy for the elimination of errors from the work of the other clerks and the orderly arrangement of results.

Mr. J. W. Whitaker made the major part of the predictions with the machine for 1889 and assisted in nearly every other kind of work. I am glad to be able to report that he has made some progress in usefulness during the year.

Miss A. G. Reville has read proofs, copied sketches, descriptions, and reductions, read maregrams, made a graphical analysis of the tide at St. Paul, Kadiak Island, Alaska, by the method of Pourtales, predicted with the machine for Smithville, Charleston, Savannah, and Fernandina, for 1889, and during the latter part of the year has assisted in examining and registering the tidal records received. Miss Reville has performed all duties devolved upon her with characteristic faithfulness, and has steadily progressed in usefulness to this Division. I think it would be only just to increase her compensation from $720 to $840 per annum.

Mrs. M. E. Nesbitt predicted from curves for Baltimore and Washington, and for Philadelphia in duplicate, for 1889, differenced the tide tables for 1889, read proof, worked on the harmonic reductions for Washington, Key West, and Kadiak Island, made non-harmonic reductions for some fifty stations, and computed on the Sandy Hook half-tide level. Mrs. Nesbitt is almost continuously employed upon heavy computations, does a large quantity of work of good quality, and I earnestly recommend that her compensation be increased from $720 to $900 per annum.

Miss C. B. Turnbull ruled forms, copied sketches and descriptions, copied and compared predictions for 1889, predicted from curves for Baltimore and Washington for 1889, and assisted on the harmonic reduction for Kadiak Island. Miss Turnbull was transferred from this Division March 1.

Miss F. Cadel was attached to this Division July 1 to 6, and again from October 3 to January 4, and was employed ruling forms, copying, reading maregrams, registering tidal records received, and summing component M for Kadiak Island.

Mrs. Virginia Harrison was attached to this Division January 5, and has been employed differencing the tide tables, reading proof, computing half-tide level Sandy Hook, working on the harmonic reduction for Kadiak Island, and in making non-harmonic reductions.

Miss Glova B. Bower, attached to this Division February 1 to April 24, was employed copying, ruling forms, reading proof, and maregrams.

Mr. S. B. Shelton was under instruction in this Division preparatory to taking charge of the Sandy Hook tidal station, from April 21 to May 21, when he resigned.

Mr. J. N. Brandon was under instruction in this Division, preparatory to taking charge of the Sandy Hook tidal station, from May 22 to June 25, when he proceeded to Sandy Hook.

The charge of this Division was continued with the undersigned throughout the year. The distribution of the work, supervision of its performance, with much minute direction to beginners, revision of results, preparation of data for charts, the Coast Pilot, field parties, and parties not connected with the Survey, the preparation of the tide tables, and elimination of errors from them while going through the press, the examination of tidal records received, and preparation of correspondence, have left me very little official time for anything else. Chiefly in non-official time I have investigated the West Florida, Cat Island, and Biloxi, and Puget Sound tides, the mean establishment and range at San Francisco and Astoria, increasing the establishment at Astoria by 23^{m}; and I have verified Prof. G. H. Darwin's report of 1883 on the Harmonic Analysis of the Tides, and taken steps, including the computation of fundamental tables, to free the Survey reductions and predictions from some rather serious errors with which they are affected.

Yours, respectfully,

ALEX. S. CHRISTIE,
Chief of Tidal Division.

Mr. B. A. COLONNA,
Assistant in charge of Office and Topography.

REPORT OF THE MISCELLANEOUS DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE FISCAL YEAR ENDED JUNE 30, 1888.

DEAR SIR: I have the honor to submit herewith the usual report of the Miscellaneous Division for the fiscal year ended June 30, 1888.

The organization of the Division remained the same as it had been in the preceding year until the 16th of December, 1887. On that date the Chart Division was established, and to it were transferred all the duties and responsibilities pertaining to the correcting, custody, and issue of charts. The establishment of this new Division, which had long been the subject of consideration, has already been justified by experience; and it is confidently believed that time will confirm the wisdom of the action taken in this behalf.

The work of the Miscellaneous Division now includes the correspondence with Sale Agents in relation to the supply and sale of publications and keeping the accounts connected with the same; the purchase, custody, and issue of stationery, the printing and issue of the Annual Reports and other publications of the Survey, and of the record books, blank forms, etc., used in the business of the office and in the field-work; the purchase of the miscellaneous supplies, the supervision of the office buildings, and such special duties as are assigned from time to time.

The following new publications were issued during the year: Tide Tables for the Atlantic Coast for 1888; Tide Tables for the Pacific Coast for 1888; Subdivision 21, Atlantic Local Coast

Pilot; "Tybee Roads to Jupiter Inlet;" Bulletin No. 1; Notices to Mariners Nos. 88 to 102, both inclusive; Tide Tables for the Atlantic Coast for 1889, and Tide Tables for the Pacific Coast for 1889. New editions of the "Laws and Regulations relating to the Coast and Geodetic Survey," and of the "Catalogue of Charts and other Publications," were also published during the year.

The Annual Reports of the Survey, the appendices to the same in pamphlet form, the Notices to Mariners, and Bulletins, were distributed as usual to the Executive Departments, Senators, and Representatives, institutions, and individuals.

Special efforts were made to distribute the Catalogue of Charts as widely as possible amongst captains of vessels and others interested in navigation, and it is believed that the largely increased demand for charts is chiefly owing to these efforts.

It is impossible to tabulate a large proportion of the work of this Division, and no tabulation whatever can be made that will convey much idea of the amount of labor involved in the transaction of its business. The following statement, however, shows the volume of the work:

Summary of work done in the Miscellaneous Division from July 1, 1887, *to June* 30, 1888.

Number of letters written (sale agents, 2209; miscellaneous, 204)	2413
Number of ledger accounts kept	77
Number of circulars issued	28
Number of orders for purchases issued	413
Number of requisitions made for printing and binding	112
Number of requisitions for stationery filled	668
Number of requisitions for miscellaneous supplies filled	676
Number of Annual Reports distributed	1152
Number of Tide Tables issued	4206
Number of Atlantic Coast Pilots issued	47
Number of Subdivisions, Atlantic Local Coast Pilots, issued	480
Number of Pacific Coast Pilots, Alaska, Part 1, issued	82
Number of charts sent to sale agents	25,273

As stated above, there was a very large increase in the sale of charts during the past fiscal year. In the fiscal year ended June 30, 1887, there were deposited with sale agents twenty-one thousand and ten copies of charts. During the fiscal year ended June 30, 1888, twenty-five thousand two hundred and seventy-three charts were sent to agents, being an increase of four thousand two hundred and sixty-three copies, and by far the largest number ever issued in any one year on that account in the history of the Survey.

Six new sale agencies were established during the year, four on the Atlantic Coast and two on the Pacific Coast. The total number of agencies on June 30, 1888, was seventy-one, viz, fifty-eight on the Atlantic and Gulf Coasts, and thirteen on the Pacific Coast.

The following table shows the aggregate of business done through the sale agencies during the fiscal year ended June 30, 1888:

Publications.	In hands of sale agents July 1, 1887.		Issued to sale agents during the year.		Sales by agents during the year.				Returned by sale agents during the year.		Remaining in hands of sales agents June 30, 1888.	
	No. of copies.	Value.	No. of copies.	Value.	No. of copies.	Value.	Amount of commissions allowed.	Net amount received.	No. of copies.	Value.	No. of copies.	Value.
Charts	16,135	$5,971.60	25,273	$10,676.25	22,669	$9,638.35	$4,818.39	$4,819.96	2,030	$770.29	16,709	$6,239.21
Tide Tables	219	54.75	3,459	864.75	2,661	665.25	332.63	332.62	84	21.00	933	233.25
Atlantic Coast Pilots	65	227.50	32	112.00	41	143.50	30.75	112.75	8	28.00	48	168.00
Subdivisions, A. L. C. P	501	311.85	280	181.95	295	186.30	44.25	142.05	40	25.05	446	282.45
Pacific Coast Pilot, Alaska, part 1	39	78.00	56	112.00	55	110.00	27.50	82.50	....	....	40	80.00
Totals of values	....	$6,643.70	....	$11,946.95	....	10,743.40	$5,253.52	5,489.88	....	844.34	....	$7,002.91

The sales made on the Eastern and Western coasts respectively were as shown in the following table:

Publications.	Atlantic and Gulf coasts.				Pacific Coast.			
	No. of copies.	Value.	Amount of commissions allowed.	Net amount received.	No. of copies.	Value.	Amount of commission allowed.	Net amount received.
Charts	19,711	$8,268.80	$4,133.68	$4,135.12	2,958	$1,369.55	$684.71	$684.84
Tide Tables	1,062	265.50	132.74	132.76	1,599	399.75	199.89	199.86
Atlantic Coast Pilots	40	140.00	30.00	110.00	1	3.50	.75	2.75
Subdivisions, A. L. C. P.	293	185.10	43.95	141.15	2	1.20	.30	.90
Pacific Coast Pilot, Alaska, part 1	9	18.00	4.50	13.50	46	92.00	23.00	69.00
Totals of values	....	$8,877.40	$4,344.87	$4,532.53	....	$1,866.00	$908.65	$957.35

The distribution of annual reports was as follows:

Date of report.	Domestic distribution—		Foreign distribution—		Total.
	To institutions.	To individuals.	To institutions.	To individuals.	
1851	1	....	1	....	2
1852	2	1	1	....	4
1853	2	3	1	1	7
1854	2	....	1	....	3
1855	2	....	1	....	3
1856	2	3	1	1	7
1857	1	1	1	....	3
1858	1	1	1	....	3
1859	2	1	1	....	4
1860	2	1	1	1	5
1861	1	3	1	....	5
1862	1	....	1	....	2
1863	1	2	2	....	5
1864	1	....	1	....	2
1865	5	2	2	....	9
1866	5	4	2	....	11
1867	5	5	3	....	13
1868	5	3	2	....	10
1869	5	4	2	....	11
1870	6	2	3	....	11
1871	7	4	4	1	16
1872	9	6	5	....	20
1873	9	10	5	1	25
1874	10	12	5	1	28
1875	10	11	5	2	28
1876	11	11	5	1	28
1877	11	13	6	....	30
1878	11	16	6	1	34
1879	11	23	5	1	40
1880	14	59	5	1	79
1881	14	60	5	1	80
1882	15	78	5	....	98
1883	15	95	5	1	116
1884	17	111	5	1	134
1885	27	241	5	3	276
Total	243	786	105	18	1,152

The following is a list of the publications of the Survey, with the number of copies of each, received from the Public Printer during the year:

Name of publication.	No. of copies.
Atlantic Local Coast Pilot, Subdivision 21—"Tybee Roads to Jupiter Inlet"	500
Tide Tables for the Atlantic Coast of the United States for the year 1888	1,987
Tide Tables for the Pacific Coast of the United States for the year 1888	2,025
Tide Tables for the Atlantic Coast of the United States for the year 1889	1,985
Tide Tables for the Pacific Coast of the United States for the year 1889	3,025
Laws and Regulations relating to the Coast and Geodetic Survey of the United States	1,025
Catalogue of Charts and other Publications, 1887	3,825
Bulletin No. 1	1,500
APPENDICES TO THE REPORT FOR 1886.	
No. 7.—Voyages of Discovery and Exploration on the Northwest Coast of America from 1539 to 1603	500
No. 8.—Monomoy and its Shoals	300
No. 9.—Shore-line Changes on Martha's Vineyard	200
No. 10.—The Delta of the Delaware	300
No. 11.—Gulf Stream Explorations. Observations of Currents, 1886	500
No. 12.—Secular Variation of the Magnetic Declination in the United States and at some Foreign Stations (sixth edition)	4,000
No. 13.—On the Circulation of the Sea through New York Harbor	300
NOTICES TO MARINERS.	
No. 88.—Chart Corrections during the Quarter ending June 30, 1887	1,000
No. 89.—Chart Corrections during Month of July, 1887	1,000
No. 90.—Chart Corrections during Month of August, 1887	2,000
No. 91.—Chart Corrections during Month of September, 1887	2,000
No. 92.—Chart Corrections during Month of October, 1887	2,000
No. 93.—Dangerous Rock in Vineyard Sound, Massachusetts	2,000
No. 94.—Gulf Stream Currents	2,000
No. 95.—Chart Corrections during Month of November, 1887	2,000
No. 96.—Chart Corrections during Month of December, 1887	2,000
No. 97.—Coast Currents, approaching Sandy Hook	3,000
No. 98.—Chart Corrections during Month of January, 1888	3,000
No. 99.—Chart Corrections during Month of February, 1888	3,000
No. 100.—Chart Corrections during Month of March, 1888	3,500
No. 101.—Chart Corrections during Month of April, 1888	3,500
No. 102.—Chart Corrections during Month of May, 1888	3,500

Mr. Freeman R. Green has continued to keep the accounts of the sale agents, and has performed various clerical duties in addition. Mr. Green's performance of his duties has been highly satisfactory and richly deserves substantial recognition.

Mr. Bassett has been in charge of the Map-mounting Room, where the work has been of the same character as in preceding years.

On the 2d of July, 1887, Mr. A. D. Simms was assigned to the Division as temporary watchman, taking the place of C. O. Rockwell, dismissed. Mr. Simms continued on this duty until July 29, when he was relieved by Mr. W. H. Keith, who had on the 25th been appointed to succeed Rockwell. The employment of William Young ceased on the 15th of July, 1887, but he was re-employed on the 18th of the same month.

Mr. W. M. Long discharged the duties of janitor, and Messrs. David Parker, John G. Culverwell, and W. H. Keith those of watchmen throughout the year.

William H. Butler, chief messenger; C. H. T. Over, Sandy Bruce, William Savoy, Peter Page, and William West, messengers; Charles H. Jones and Attrell Richardson, packers and folders; W. R. McLane, driver; Horace Dyer and Harrison Murray, firemen; Mrs. S. E. Flynn, William Young, J. H. Brown, and Robert Brady, laborers, all deserve mention for the intelligence and fidelity with which they performed their several duties.

Yours, respectfully,

M. W. WINES,
General Office Assistant.

B. A. COLONNA, Esq.,
Assistant in charge of Office and Topography.

REPORT OF THE ARCHIVES AND LIBRARY DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE FISCAL YEAR ENDING JUNE 30, 1888.

COAST AND GEODETIC SURVEY OFFICE,
Washington, D. C., August 28, 1888.

DEAR SIR: I have the honor to submit herewith the annual report of the receipt and registry in the Archives of original and duplicate records, computations, completed original topographic and hydrographic sheets, and specimens of sea-bottom, turned into the Office during the fiscal year ending June 30, 1888, as hereinafter enumerated; and also, of the books and pamphlets received in the Library during the same time.

I.—*Records and Computations.*

GEODETIC WORK.

	Number of volumes.		Number of cahiers.	Number of packages.	Total.
	Original.	Duplicate.	Original.	Original.	
Observations of horizontal measures	181	161			342
Observations of vertical measures	24	24			48
Descriptions of stations	22	21			43
Base measurement	1	2			3
Beach measurement	1	1			2
Spirit-leveling observations	73	62			135
Rod-books	9				9
Descriptions of bench-marks	4	3			7
Maps showing route lines of levels	3	1			4
Determination of constants	4	4			8
Geodetic miscellany	10	6			16
Views and sketches	2			1	3
Computations			224		224
Totals	334	285	224	1	844

ASTRONOMICAL WORK.

	Number of volumes.		Number of cahiers.	Number of sheets.	Total.
	Original.	Duplicate.	Original.	Original.	
Observations for latitude	8	20			28
Observations for longitude		10			10
Chronograph sheets				64	64
Observations for time	14	14			28
Observations for azimuth	11	9			20
Micrometer measure	1	1			2
Chronometer comparison record	1	1			2
Computations	2		37		39
Total	37	55	37	64	193

I.—*Records and Computations*—Continued.

MAGNETIC WORK.

	Number of volumes.		Number of cahiers.		Number of sheets.		Total.
	Original.	Duplicate.	Original.	Duplicate.	Original.	Duplicate.	
Observations for terrestrial magnetism	2	2	37	36	60	......	137
Magnetic traces	......	......	......	......	555	555	1,110
Computations	......	......	11	......	80	......	91
Total	2	2	48	36	695	555	1,338

PENDULUM WORK.

	Number of volumes.		Number of sheets.		Total.
	Original.	Duplicate.	Original.	Duplicate.	
Pendulum observations	9	9	......	......	18
Sheet readings	......	9	......	......	9
Chronograph sheets	......	......	133	......	133
Total	9	18	133	......	160

METEOROLOGICAL WORK.

	Number of volumes.		Number of cahiers.		Total.
	Original.	Duplicate	Original.	Duplicate.	
Meteorological observations	2	......	1	......	3
Total	2	......	1	......	3

HYDROGRAPHIC WORK.

	Number of volumes.		Number of cahiers.		Number of bottles.	Number of rolls.	Total.
	Original.	Duplicate.	Original.	Duplicate.			
Observations for soundings	366	226	......	......	......	......	592
Observations for angles	36	22	......	......	......	......	58
Descriptions of hydrographic signals	4	......	......	......	......	1	5
Specimens of sea-bottom	......	......	......	......	447	......	447
Tidal observations	111	95	......	......	......	......	206
Maregrams and tidal curves	......	......	......	......	......	88	88
Description of tide gauges and bench-marks	......	......	1	1	......	......	2
Current and Gulf Stream observations and data	11	11	14	......	......	......	36
Miscellaneous	7	......	7	1	......	......	15
Movement of ice	......	4	1	......	......	......	5
Log-books	24	......	......	......	......	......	24
Total	559	358	23	2	447	89	1,478

II.—*Topographic and Hydrographic Surveys.*

TOPOGRAPHIC WORK.

Register number.	Titles of topographic sheets.	No. of sheets.	Descriptive reports accompanying.
1633	From head of East Bay (Galveston Harbor) to Sabine Pass, Fla	1	....
1703	Harlem River from Randall's Island to High Bridge, N. Y	1	....
1719	Newark Bay and mouths of Passaic and Hackensack Rivers, N. J	1	....
1722	Hempstead Harbor, Long Island, N. Y	1	....
1727	North shore of Long Island from Rocky Point Landing to East Landing, N. Y	1	....
1728	North shore of Long Island from East Landing Wading River to Roanoke △, N. Y	1	....
1729	North shore of Long Island from Roanoke △ to Mattituck Hills 2 △, N. Y	1	....
1730	North shore of Long Island from Mattituck Hills 2 △ to Goldsmith's Inlet	1	....
1731	Lloyd's Neck and adjacent shores, Long Island, N. Y	1	....
1733	Oyster Bay, Long Island, with shore to Matinicock Point, N. Y	1	....
1735	Block Island, R. I	1	....
1737	Norwalk River to Holly's Point, Conn	1	....
1743	Hudson River from Eightieth street to Spuyten Duyvil Creek	1	....
1744	Coast of New Jersey above and below Great Egg Harbor, N. J	1	....
1753	Coast of California from Villa Creek to Creek △, Cal	1	....
1754	Yaquina Bay and part of Yaquina River, Oregon	1	....
1757	Umpquah River, Oregon	1	....
1768	Umpquah River, including Gardiner City, Oregon	1	....
1772	South shore of Little Peconic Bay, Long Island, N. Y	1	1
1773	North shore of Great and Little Peconic Bays, Long Island, N. Y	1	1
1774	South shore of Great Peconic Bay, Long Island, N. Y	1	1
1775	West shore of Great Peconic Bay, Long Island, N. Y	1	1
1776	Coast of Oregon from Yaquina Head to Cascade Head, Oregon	1	1
1777	Coast of Oregon from Cascade Head to Tillamook Bay, Oregon	1	1
1778	Coast of Oregon from Cape Meares to Tillamook Bay, Oregon	1	1
1781-'83, 1786-'90	Reconnaissance Gray's Harbor to Cape Flattery, Wash. Ter	9	1
1784	Topography from Santa Rosa Creek to San Simeon Bay, Cal	1	1
1791	Topographical sketch of the proposed harbor of Port Ballona, Cal	1	....
1792	The town-sites of Long Beach and Alamitos Beach, Los Angeles County, Cal	1	....
1793, 1803, 1804	Resurvey of Suisun Bay, Cal	3	2
1794	Rosario Strait. Cuemes, Samish, and Vendovi Islands, Wash. Ter	1	1
1795	Rosario Strait. Samish Bay, Wash. Ter	1	1
1796	Rosario Strait. Samish Flats to Bellingham, Wash. Ter	1	1
1797	Rosario Strait. Lummi and Eliza Islands and Point Frances, Wash. Ter	1	1
1798	Rosario Strait. North part of Bellingham Bay, Wash. Ter	1	1
1799	Rosario Strait. Nooksachk River, Wash. Ter	1	1
1802	A portion of Martha's Vineyard Island, Mass	1	1
1806	Resurvey of Astoria and vicinity, Oregon	1	1
1807, 1808	Part of San Diego Bay, Cal	2	....
1817	American Bottom Base, Ill	1	1
1818	Great Point and Nantucket Harbor, Mass	1	....
1822	Atchafalaya River from Atchafalaya Bay to Sword Point, La	1	1
1823	Atchafalaya River from Sword Point to Bateman's Lake, La	1	1
1824	Atchafalaya River from Bateman's Lake to Morgan City, La	1	1
1825-'27	Resurvey of San Pablo Bay, Cal	3	1
1829	From San Carpoforo Creek to White Rock No. 2, Cal	1	1
	Total	59	....

HYDROGRAPHIC WORK.

1455b	Upper part of Chincoteague Bay, Md	1	....
1676	Lompoc Landing, Cal	1	....
1681	Pacific Coast from Wyman to Punta Gorda, Cal	1	....
1682	Pacific Coast from Punta Gorda to Cape Mendocino, Cal	1	....
1704	Hell Gate and vicinity, N. Y	1	....
1711	Columbia River from Columbia City to head of Bachelor Island, Oregon	1	....
1712	Raritan Bay, N. Y. and N. J	1	....

II.—*Topographic and Hydrographic Surveys*—Continued.

HYDROGRAPHIC WORK—Continued.

Register number.	Titles of hydrographic sheets.	No. of sheets.	Descriptive reports accompanying.
1713	Arthur Kill, Ward's Point to Woodbridge Creek, N. Y. and N. J	1	....
1714	Arthur Kill, Woodbridge Creek, to Fresh Kills, N. Y. and N. J	1	....
1715	Arthur Kill, Fresh Kills to Dividing Creek, New York Harbor, N. Y. and N. J	1	....
1716	Staten Island Sound, and lower part of Newark Bay, New York Harbor, N. Y. and N. J	1	....
1717	Upper part of Newark Bay, New York Harbor, N. Y. and N. J	1	....
1718	Off Sandy Hook entrance to New York Harbor, N. Y. and N. J	1	....
1719	The Narrows, New York Harbor, N. Y.	1	....
1728	Possession Sound, Wash. Ter	1	....
1729	Admiralty Inlet from Admiralty Head to Foulweather Bluff, Wash. Ter	1	....
1730	Port Susan, Wash. Ter	1	....
1737	Wrangell Strait, S. E. Alaska	1	....
1738	St. John Harbor, S. E. Alaska	1	....
1739	Dewey Anchorage, Alaska	1	....
1740	Steamer Bay, Alaska	1	....
1741	Etolin Harbor and Highfield Anchorage, Southeast Alaska	1	....
1742	Clarence Strait and adjoining channels, Point Lemesurier to mouth of Stikine River, S. E. Alaska	1	....
1744	Sketch of Ratz Harbor, Prince of Wales Island, Alaska	1	....
1745	Sketch of Ratz Harbor, Coffman's Cove, Prince of Wales Island, Alaska	1	....
1746	Hydrography of Umpquah River, Oregon	1	....
1749	Sumner Strait, S. E. Alaska	1	....
1755	Port Protection, Alaska	1	....
1756	Port McArthur, Alaska	1	....
1757	Shakan Straits, Alaska	1	....
1758	Red Bay, Alaska	1	....
1762–'63	Dredged channel, Atchafalaya Bay, La	2	....
1765	Off Coast of Louisiana, from Southwest Pass, Mississippi River, to longitude 89° 35′, La	1	....
1766	Off Coast of Louisiana, from longitude 89° 35′, La	1	....
1767	Cote Blanche Bay, La	1	....
1768	Fanshaw Bay, La	1	....
1769	Coast of North Carolina, from Federal Point to Smith's Island, N. C	1	....
1770	West Coast of Florida, Chassahowitzka Bay to Crystal River, Fla	1	....
1771	West Coast of Florida, Crystal River to Cedar Keys, Fla	1	....
1772a	Examination of bar, entrance to Cedar Keys Harbor, Fla	1	....
1772b	Examination of Middle Ground Cut, Cedar Keys, Fla	1	....
1773–'74	West Coast of Florida, from Cape Romano to the southward, Fla	2	....
1775	Entrance to St. Simon's Sound, Ga	1	1
1778	White Rock to Wyman, Cal.	1	....
1779	Karquines Strait, from Mare Island to Bull's Head, Cal	1	1
1780	Suisun Bay, from Bull's Head to Middle Point, Cal	1	1
1781	Suisun Bay, from Stephenson Point to N. Y. Point, Cal	1	1
1782	Off-shore soundings, from Phelps Bank to Montauk Point	1	....
1787	Approaches to Narragansett Bay and Block Island Sound, R. I	1	1
1788	Approaches to Narragansett Bay and Vineyard Sound, R. I	1	1
1789	Coast of Rhode Island, from Brenton's Point to Point Judith, R. I	1	1
1790	Coast of Rhode Island Sound, Sachuest Point to Brenton's Point, R. I	1	1
1791	Coast of Rhode Island, Tunipus Beach to Sachuest Point, R. I	1	1
1792	Coast of Massachusetts, from Black Rock to Tunipus Beach, R. I	1	1
1799	Shoalwater Bay and Approaches, Wash	1	1
1800	Pacific Coast, from Shoalwater Bay to Gray's Harbor, Wash. Ter	1	1
1801	San Pablo Bay, Cal	1	1
1802	Entrance and Southern Approaches to Vineyard Sound, Mass	1	....
1803	Inside waters, Powell's Bay to Floyd's Bay, Va	1	....
1804–'06	Frederick Sound and vicinity, S. E. Alaska	3	....
1807	Entrance to Duncan Canal, Alaska	1	....
1808	Duncan Canal, Alaska	1	....
1809	Upper part of Duncan Canal, Alaska	1	....
1810	Brown Cove, Alaska	1	....
1811	Thomas's Bay, Alaska	1	....
1812	Farragut Bay, Alaska	1	....
1813	Portage Bay, Alaska	1	....
1816	Inside waters, coast of Delaware and Maryland, from Miller's Creek to Sinepuxent Bay, Del. and Md	1	....
1817–'18	Cross-sections off Nausett Beach, Cape Cod, Mass	2	....
	Total	74	

From what precedes it will be seen that there have been registered in the Archives during the fiscal year ending June 30, 1888, 619 volumes and 1 package of geodetic observations; 224 cahiers of geodetic computations; 26 cahiers of descriptive reports on topographic sheets; 92 volumes and 37 cahiers of astronomical observations and computations; 64 chronograph sheets; 4 volumes, 73 cahiers, and 60 sheets of magnetic observations; 1,110 sheets of magnetic traces; 11 cahiers and 80 sheets of magnetic computations; 27 volumes of pendulum observations; 133 chronograph sheets; 2 volumes and 1 cahier of meteorological observations; 917 volumes and 23 cahiers of hydrographic observations; 1 roll of hydrographic observations; 447 bottles of specimens of sea-bottom, and 88 tide rolls; 13 cahiers of descriptive reports on hydrographic sheets; 59 completed topographic sheets; 74 completed hydrographic sheets.

There has been no binding of records or computations done this fiscal year, although there are a great number that should be bound for their better preservation, convenience of reference, and to give needed room.

The soundings and tidal observations ought also to be bound, as they would then occupy much less space than in their present condition, and room will soon be *needed.*

During the past fiscal year there have been received in the Library 201 bound volumes, 96 unbound volumes, and 168 pamphlets, besides a number of periodicals and publications of scientific societies.

Thirty-one volumes have been substantially bound at the Government Bindery. Most of these were rebound, the original binding being in a bad state. One hundred and twenty-eight other volumes were sent to the Bindery for binding, but they were not returned to the Library till *after* June 30, 1888.

There are still quite a number of volumes that need rebinding, and many unbound works that should be bound.

Mr. J. M. Duesberry has been employed in this Division as clerk during this fiscal year.

Mr. Joseph Fuqua was employed in the Library on the card catalogue from May 11, 1888, to May 19, 1888, and from June 4, 1888, to June 12, 1888.

Miss Florence Carlisle was employed in the Library on the card catalogue from May 28, 1888, to June 30, 1888.

Mr. Atlee Johnson was employed a few days from May 28, 1888, sorting books in the fourth story of the Butler Building, and in bringing the same down and putting them on the tops of the cases in the Library.

The card catalogue is nearly finished.

Yours, respectfully,

ARTEMAS MARTIN,
Librarian and Custodian of Archives.

Mr. B. A. COLONNA,
Assistant in charge of Office.

REPORT OF THE ACCOUNTING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE FISCAL YEAR ENDING JUNE 30, 1888.

ACCOUNTING DIVISION, U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, November 15, 1888.

SIR: I have the honor to submit herewith the report of the operations of the Accounting Division for the fiscal year ending June 30, 1888. The work of the Division is so varied in its character that a complete report can not be made without a reference to those salient events occurring during the year which were liable, to a greater or less extent, to affect its operations, and to increase or diminish its efficiency. These will, therefore, be alluded to in the course of the report.

Commencing July 1, 1887, a system of making semi-monthly trial balances and monthly balance-sheets, showing in detail the receipts and expenditures of the Survey under the appropriations made by Congress, was inaugurated, and has since been adhered to with much success and great satisfaction to all concerned. These balance-sheets are made in triplicate—one each for the Secretary of the Treasury, the Superintendent, and the Disbursing Officer—and they afford a convenient method for readily verifying the financial condition of the Survey, and serve as a check against errors. Their preparation is now mandatory under the Regulations.

On July 25, 1887, a special committee, composed of Messrs. Spear and Myers, of the First Comptroller's office, appointed by the Secretary of the Treasury, made a personal investigation and examination of the accounts and records of the Division, and on the following day officially reported to the Department that the accounts of the Survey were found correct and in exact balance. Every facility and courtesy was extended to the committee, and the result, so promptly reached, was a deserved tribute to the efficacy of the "balance-sheet" system so auspiciously begun on the first of the month, the labors of the committee consisting simply in checking off the amounts given on the balance-sheet and proving their correctness.

As a consistent step towards the organization of the methods of work in the Division, the following-named new forms and blanks were prepared during the months of October and November, 1887, and received the approval of the Superintendent for adoption and printing:

Field estimates for chiefs of parties (amended), balance sheet blanks for Office, Office payrolls, cash receipts and expenditures, annual statement book for fiscal year, letter returning property lists, letter authorizing advances, letter for adjusting accounts, letter transmitting advances, letter for stating balances on accounts, letter for transmitting checks.

The use of these new forms and records has aided most materially in lessening clerical labor, and affords a more complete and satisfactory record of work accomplished.

During July and August, 1887, a series of salary tables, comprising all the new rates per annum (twenty-three in all) established for the service by the Sundry Civil Act, approved March 3, 1887 (in addition to those already given in the Government salary tables), were computed in this Division, upon the basis of the regular tables, and these computations were afterwards verified by the Computing Division. These new tables have been found of very great convenience in checking the pay-roll and salary accounts, as the use of them avoids the laborious process of combining two or more of the old tables together in order to arrive at one rate.

The new edition of the Regulations (1887) was proof-read and indexed by me during the early part of August, 1887. A recommendation that a number of copies of the new edition be interleaved and rebound, for convenience in making notes or criticisms from time to time, such as the future enforcement of the Regulations would no doubt suggest, was concurred in by the Superintendent.

The annual Report of Expenditures of the Coast and Geodetic Survey for the fiscal year ending June 30, 1887, was completed and transmitted to Congress on February 11, 1888. The delay in the final completion of this report was unavoidable, and owing to circumstances entirely beyond my control. It should have been presented to Congress during the month of December, and the failure to do so occasioned me much regret.

The almost continual disallowance by the accounting officers in the accounts of the Survey of alleged overcharges on fees paid for jurats induced me to make efforts to secure information upon which to formulate a list of the legal rates for notarial fees in the different States. The files of the Comptroller's and Auditor's offices, the Bureau of Labor, and the Congressional Library were examined, and from the data obtained, a list, believed to be fairly correct, was compiled. This list has been distributed among the chiefs of the parties of the Survey, with the suggestion that further advices upon the subject would be thankfully received by this Office. In time, it is hoped that a perfectly correct list may be obtained, through the kind co-operation of the Field Officers.

During the year, for a period of forty-four days, my services were called into requisition by the First Comptroller of the Treasury, to aid in the final examination and adjustment of the accounts of Mr. William B. Morgan, late Disbursing Agent. This detail was no doubt proper and necessary, but the loss of time from my own legitimate duties in the Accounting Division was a source of much embarrassment and occasioned much delay in the transaction of current business.

From May 19 to June 9, 1888, I was engaged, under instructions from the Superintendent, in transferring the United States schooner *Spy* from New York, N. Y., to Washington, D. C. Complete details as to this duty, and the manner in which it was accomplished, have been made the subject of a special report to the Superintendent.

The current work of the Division during the fiscal year has been adjusted with a degree of promptitude heretofore unknown in the history of the Accounting Division. But few instances of delay in the settlement of accounts have occurred, and these were mainly owing to my enforced absence on duty at the Department. During the first six months of the fiscal year the force attached to the Accounting Division was also quite inadequate to the demands made upon it, and but for the detail of another employé therein early in January, 1888, the current work would have fallen greatly in arrears. Some delay must necessarily result under our present system of making disbursements, but it has always been my earnest effort to neutralize this as much as possible by giving extra time to the business of the Division. The Quarterly accounts of the Survey have been rendered to the Auditor more promptly during the last fiscal year than has been the case for several years past. This gain is quite gratifying, under the circumstances.

In my last Annual Report, and also in the Monthly Report for September, 1887, I have called attention to the necessity for some arrangement by which a greater degree of privacy and consequent freedom from interruption could be secured for the employés of this Division. A counter, surmounted by the usual screen-work, should be erected in the rooms of the Accounting Division at as early a date as may be practicable. I again renew my former recommendations to this effect. Such action would be in the line of a sound business policy, and would contribute largely to the essential features of accuracy and rapidity in the transaction of the current business of the Division.

It is almost impossible to give intelligible statistics for work such as that accomplished in this Division. The nearest approach is to state its volume. The mere examination of the number of accounts adjusted, letters written, etc., affords but a slight conception of the innumerable details to which attention has to be given. The statistics which follow, therefore, while the best that can be stated, are not to be considered by any means as covering every feature of the work:

Statistics.

Abstracts, quarterly, of disbursements, pages of	139
Accounts, with United States, opened, number of	16
Accounts, allotments, opened, number of	144
Accounts, subappropriations, opened, number of	74
Accounts, Pacific railroads, referred, number of	37
Accounts, entered on quarterly abstracts, number of	1,882
Accounts-current, with United States, number of	30
Accounts posted, to allotments, number of	886
Accounts posted, to calendar-year book, number of	998
Accounts posted, to fiscal-year book, number of	1,512
Accounts posted, to voucher-book, number of	2,564
Advances, to Field Officers, amount of	$128,262.83
Allotments, to Field Officers, number of	200
Authorities, book of, letters posted to, etc., number of	528
Balance-sheets, receipts and disbursements, number of	12
Cash-book, entries in, checks and cash	2,945
Certificates of deposit, received, acted on, and filed	36
Check-lists, for drawing checks, number of	203
Checks, drawn and issued, number of	2,594
Copying, miscellaneous, pages, number of	480
Disbursements, on adjusted accounts, amount of	$473,177.77
Drafts, Treasury, received, number of	26
Estimates, of Field Officers, received, number of	193
Letters, received, acted on, and filed	3,202
Letters, written and press-copied	3,294
Letters, indexed, letter-book	3,294
Letters, rough drafts of, written	2,469
Pay-envelopes, prepared, number of	1,956

Pay-rolls, office, monthly and semi-monthly, pages of	288
Pay-rolls, Field Officers, quarterly, pages of	36
Property lists, checked and returned	339
Receipts, of funds, from Treasury, amount of	$493, 099. 13
Reports, monthly, of Division, pages of	252
Reports, annual, calendar year, pages of	10
Reports, fiscal year, pages of	65
Requisitions, on Treasury, for funds, number of	10
Requisitions, from Field Officers, for advances, number of	240
Statements, of condition of appropriations, pages of	24
Trial balances, receipts and disbursements, number of	25
Vouchers, adjusted and settled, including bills, number of	18, 916

A recapitulation of data contained in the monthly reports of the Division for the fiscal year just closed indicates the following:

Summary for all employés.

	Days.
Actual number of days worked	1,238¾
Absences, sick	87½
Absences, leave	103½
Office closed, holidays, etc	31¾

Divided as follows:

Name.	Worked.	Absent, sick.	Absent, leave.	Office closed.
	Days.	*Days.*	*Days.*	*Days.*
Parsons, John W	327	7½	*21½	1
Wills, Eugene B	260¼	22½	28	9¼
Lanman, W. H	145½	....	1	3
Taliaferro, S. M	250¾	27½	29½	9¼
Smith, Paula E	255¼	30	23½	9¼

* Working at home for eleven and one-half days, which was charged to leave account.

The total number of working days during the year on which the Office was open for the transaction of business was 304¾.

The arrangement of the work of the Division among its employés has been about as follows:

Mr. Eugene B. Mills, accountant, has been engaged in the examination of accounts, checking them as to errors of enumeration, extension, etc., in drawing checks at the Department, and mailing the correspondence of the Division. He deserves credit for close application to his work.

Mr. W. H. Lanman, general book-keeper, was assigned to duty in the Division on January 9, 1888, by transfer from the Hydrographic Inspector's Office. His experience of nearly two years in the office of the disbursing clerk of the Treasury Department, prior to his employment in the Survey, has made him a valuable addition to the force of the Division. His work is mainly dependent upon my own, and its execution has given me much satisfaction.

Mrs. S. M. Taliaferro, book-keeper and entry clerk, has been engaged mainly in entering and posting vouchers, etc., to the various account books of the Division, in the compilation of the Quarterly Abstracts, and general miscellaneous work.

Miss Paula E. Smith, general clerk, has had charge of the preparation of the semi-monthly and monthly pay-rolls and the letter files, and has rendered intelligent and capable service in the execution of innumerable details of the work.

The experience of another year has convinced me more than ever that the Survey should possess its own Disbursing Officer. The present arrangement for making disbursments is at once both cumbersome and annoying, produces delay in settlements, and by comparison of results will be found much more expensive than almost any other method we could adopt. It is the outcome of the peculiar conditions which existed in the Survey some three years since, conditions which no longer exist, and it should now be abandoned in the interests of sound public economy. Comparisons can be readily made to prove the costliness of the present system. The work of the Division is constantly increasing in volume, and the time now lost in communicating with the Department and in the preparation of papers essential to a proper record under the present system could be saved by the appointment of a Disbursing Clerk for the Survey and given to the current business of the Office. In this connection, I beg to refer you to the views expressed by me upon this subject in my annual report for the fiscal year ending June 30, 1887.

Mr. George A. Bartlett, Disbursing Clerk of the Treasury Department, has displayed his usual interest in making the disbursements for the Survey. The business of the Division has, as heretofore, been conducted in his name, and in all matters pertaining to the adjustment of his accounts by the accounting officers of the Treasury he necessarily assumes full responsibility. The obvious propriety of compensating Mr. Bartlett for this responsibility can not be questioned. My views upon this matter are more fully expressed in the report of the Division for the fiscal year 1886–'87.

Yours, respectfully,

JOHN W. PARSONS,
Computer U. S. Coast and Geodetic Survey,
In charge Accounting Division.

B. A. COLONNA, Esq.,
Assistant U. S. Coast and Geodetic Survey,
In charge of Office and Topography.

REPORT OF THE BUREAU OF WEIGHTS AND MEASURES FOR THE FISCAL YEAR ENDING JUNE 30, 1888.

BUREAU OF WEIGHTS AND MEASURES,
U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, July 19, 1888.

SIR: I beg leave to submit this report on the work of the Weights and Measures Division under my charge since October 7, 1887:

The letter of instructions from the Superintendent assigning me to this duty directed me to prepare for publication the Weights and Measures report, compiled chiefly by the late assistant, H. W. Blair, under the direction of Prof. J. E. Hilgard, then Superintendent, but not subjected to the latter's final revision. Upon perusal of the manuscript I found it necessary to index the records of the Weights and Measures Office. The time occupied in the completion of this preliminary work and the current work of the Office has prevented me from putting the report into final shape for the printer.

The laborious work of classifying, cataloguing, and indexing the papers of this Office accumulated since 1844 was performed by Sub-Assistant F. H. Parsons with care and good judgment while attached to this Division from November 23 to May 10. The records and correspondence up to the time of my assuming charge are now bound and on file in the Archives.

Dr. J. J. Clark, adjuster, whose long experience and knowledge of details freely rendered assisted me materially, made all the weighings and assisted in the comparisons of standards, in calibrating a thermometer and in other work. He also prepared the weights and measures exhibit for the Cincinnati Centennial Exhibition.

Assistant J. B. Weir was attached to this Division during the months of March and April and again during June. He was engaged in making and revising computations of work done under my direction and previously. He also assisted in the comparison of standards.

The principal results of the work done on the standards will be given elsewhere, but a brief account may not be out of place here.

The Arago kilogramme sent to England in 1879, and weighed at the Standards Office in that year against the English Standard Kilogramme, was taken to the International Bureau in 1884 and weighed against the International Standard. Since then the English Kilogramme has also been compared with the International and the outstanding difference formed by the equations thus established is less than 0.1 milligramme.

The Arago Kilogramme was also weighed under my direction with the gilt Silbermann Kilogramme and with the brass Star Kilogramme of this Office, and it appears that while the relation of the Arago (platinum) Kilogramme to the Silbermann (gilded brass) has not changed sensibly since 1873, the Star (brass) Kilogramme has not preserved its weight as perfectly, having gained more by oxidation than it has lost by abrasion. This is in accordance with previous experience. It was in view of this fact that I requested you to authorize the Electrotyping Division to make experiments on gilding weights of the composition (Hassler brass) used in this Office as working standards.

A necessary comparison was also made by me between the two British standard Yards, Iron No. 57 and Bronze No. 11. An account of the comparison of these two yards with each other and of No. 11 with the Imperial standard was published in Appendix 12, Report for 1876; since then, for reasons stated in that appendix, No. 57 was sent abroad and was compared in London with the Imperial Standard; it was returned to this Office in 1884, but no comparison was made after its return between it and No. 11 until the recent one made by me. The result of these subsequent comparisons has shown the correctness of the lengths assigned to Bronze No. 11 and Iron No. 57 in Appendix 12, Report for 1876, above quoted.

Though the courtesy of Prof. Henry Morton, President of the Stevens Institute of Technology, a Hassler brass bar, belonging to the Institute, which had been compared at the International Bureau with its standard was loaned to this Office and was compared with its fellow Yard and Metre No. 1, at the prevailing temperature of the comparing room. Berlin Metre No. 49, largely used in pendulum work, was then compared with Yard and Metre No. 1, and thus related to the International Metre. Hitherto No. 49 has been referred to the International Standard through the comparisons of Professor Foerster at Berlin. The two values thus obtained are not strictly comparable because the co efficient of expansion of Yard and Metre No. 1 is not accurately known, and although it can be derived from further comparisons, at a lower temperature, with No. 49 they will have to be deferred until fall when the temperature of the comparing room is lower. The urgent necessity for a room whose temperature can be artificially controlled is well known to you, but is again made apparent by these facts.

The comparisons made with Metre No. 49 show that the latter is not well adapted to its original purpose, that of serving as a standard of reference, because the defining lines are of irregular width and too coarse and deep to meet modern requirements. The effect of the illumination on the appearance of these lines was brought out incidentally by the comparisons recently made in which the conditions were so varied as to show this source of error.

In this connection it should be mentioned that the Tolles illuminating prisms in the microscopes have not, as at present arranged, given satisfaction and recourse was again had to the old form of an external reflector under the objective. The microscopes of the comparator have been supplied with levels and their mounting has been changed. A set of comparisons was made to test whether the beam compass microscopes of the comparator maintain their relative position when the beam compass carrying them is moved to and fro. The comparisons so far made indicate that the effect is very slight.

In the way of experiment the direct comparison between two end measures and between a line and end measure was made on the comparator in the same way as the comparisons between two line measures are made, with satisfactory results.

This method is a modification of that of Fizeau, and as far as known to me has not been practiced before. The end bars are prepared for comparison by stretching a spider thread across the abutting surfaces. The direct and reflected images of the threads are seen separated by a line of light from two to five microns wide, on which the pointings are made.

In conclusion I append an abstract of information furnished by this Division.

Yours respectfully,

O. H. TITTMANN,
Assistant, U. S. Coast and Geodetic Survey.

Mr. B. A. COLONNA,
Assistant in charge of Office and Topography,
Washington, D. C.

Abstract of information furnished by the Weights and Measures Division from October 7, 1887 to June 30, 1888.

Date.	Name.	Source.	Remarks.
1887.			
Oct. 20	Fairbanks & Co	St. Johnsbury, Vt	Weighings of a set of troy and avoirdupois ounces.
Nov. 5	Sub. Asst. Van Orden	Coast and Geodetic Survey	In regard to length of tape.
Dec. 1	Wm. P. Mason	Troy, N. Y	In regard to definition of legal gallon.
Dec. 3	Louis Bell	Johns Hopkins University	In regard to certain metric scales.
Dec. 6	Col. P. C. Harris	U. S. Engineers	In regard to length of tape.
Dec. 7	E. D. Preston	U. S. Coast and Geodetic Survey	In regard to thermometric comparisons.
Dec. 21	E. D. Preston	U. S. Coast and Geodetic Survey	Do.
Dec. 29	Prof. I. T. Osmond	State College, Pa	In regard to standards for agricultural colleges.
1888.			
Jan. 3	Asst. C. S. Peirce	U. S. Coast and Geodetic Survey	Results of pendulum weighings.
Jan. 23	F. O. Maxon, C. E	U. S. Navy	Results of tape comparison.
Feb. 2	Keuffel & Esser	New York	Comparison of yard and meter bar.
Feb. 18	Wm. G. Steinmetz, C. E	Washington	Results of tape comparison.
Mar. —	Prof. Wm. Harkness	U. S. Transit of Venus Commission	Results of comparison of standard inch.
Mar. 19	Asst. C. S. Peirce	U. S. Coast and Geodetic Survey	Results of comparisons of meter B and No. 49.
Mar. 30	Prof. J. Torrey	Iowa College	Results of comparison of metric weights.
Mar. 30	Prof. Geo. H. Cook	New Brunswick, N. J	Results of tape comparison.
Mar. 31	Instrument Division	U. S. Coast and Geodetic Survey	Results of tape comparison.
May 2	Chief of Ordnance	U. S. Army	Results of comparisons of 18 rods and 8 round gauges.
May 14	A. H. Sabin	Long Island	Relative to legal capacity measures.
May 12	E. D. Preston	U. S. Coast and Geodetic Survey	Results of thermometer comparisons.
June 2	F. O. Maxon, C. E	U. S. Navy	Results of tape comparisons.
June 6	American Machine Company	Philadelphia	Results of weighings.
June 12	E. D. Vance	Kinsman, Ohio	In regard to tape lines.
June 19	Chief Hydrographer	U. S. Navy	Result of tape comparison.
June 25	Asst. J. B. Baylor	U. S. Coast and Geodetic Survey	Do.
June 27	American Machine Company	Philadelphia	Result of weighings.
June 30	Prof. Wm. Harkness	U. S. Transit of Venus Commission	Result of length comparisons.

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APPENDIX No. 5.—1888.

REPORT OF THE HYDROGRAPHIC INSPECTOR FOR THE YEAR ENDING JUNE 30, 1888.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, D. C., October 31, 1888.

SIR: I have the honor to submit the following report on the hydrographic work under my charge, and on the condition of the vessels of the Survey, and the repairs made to them during the fiscal year ending June 30, 1888.

HYDROGRAPHY—COAST OF MAINE.

The beginning of the fiscal year found the steamer *Gedney*, Lieut. F. H. Crosby, U. S. N., commanding, on the coast of Maine, the party having arrived on the working ground on June 11. Lieutenant Crosby closed work on the 19th of October, having in the mean time finished the hydrography of Passamaquoddy Bay from Eastport to the mouth of St. Croix River—the survey of the St. Croix River from its mouth to Calais—and sheet No. 1 of Cobscook Bay. In addition to the regular work on the coast of Maine, Lieutenant Crosby made examinations in Penobscot River and in the vicinity of Machias Seal Islands. The *Gedney* returned to New York late in October and was immediately put in condition for further service in the Gulf.

VINEYARD SOUND.

The schooner *Eagre*, Lieut. C. P. Perkins, U. S. N., commanding, having been engaged in Long Island Sound on current work and in making examinations and developing shoal spots, moved to Vineyard Sound a few days before the beginning of the fiscal year. The party was a large one and had attached to it, in addition to the *Eagre*, the steamer *Daisy*, three large steam-launches, and a small Herreshoff launch. This obviated the necessity for delay in case of the breaking down of one of the boats. The work of the party in the *Eagre* was principally confined to Vineyard Sound, extending out as far as No Man's Land, which is rather beyond the limits to which steam-launch parties should work. This was shown on one occasion when a gale of wind coming up suddenly, the *Daisy* started to convoy and tow the Herreshoff launch back to a secure anchorage inshore, but unfortunately the launch foundered on the way in.

The steamer *Bache*, Lieut. J. F. Moser, U. S. N., commanding, arrived in Vineyard Sound at the beginning of the year, and was very successful in extending the hydrography from Block Island to Martha's Vineyard. The usual delays and interruptions were occasioned by fogs and bad weather, but notwithstanding this the progress was very rapid.

The *Bache* closed work on the 4th of November and proceeded to Baltimore to refit for work on the coast of Florida.

The *Eagre* closed work on the 5th of November and proceeded to New York, at which place all the officers were detached with the exception of the chief of the party, who remained with the recorder to get the records in shape for sending to the office. During the winter the party on board the *Eagre* made special examinations near Lawrence Point, East River, and at New York entrance. Lieutenant Perkins was detached from the Survey February 28, 1888, and was succeeded in command of the *Eagre* by Lieut. Sumner C. Paine, U. S. N.

The *Eagre* left New York in May, 1888, to proceed to the eastward and continued the resurvey of Vineyard Sound. Lieutenant Paine was directed to stop at Stonington, Conn., and make a special examination of Noyes's Shoal off the entrance to Stonington Harbor. Upon the completion of this service the regular work of the party in Vineyard Sound was taken up and was in progress at the close of the fiscal year.

The necessity of the resurvey of Vineyard Sound is shown by the great changes that have been developed in various places, this being especially marked near the eastern limits. For instance, a report of the grounding of the steamer *Orion* on a shoal to the eastward of Great Round shoal having been received through the Branch Hydrographic Office at Boston, the commanding officer of the *Gedney* was directed to make an examination at as early a date as practicable. A shoal was developed with least depth of fifteen feet of water where the former survey gave over seven fathoms, and this well outside of all the numerous shoals which lie between Nantucket and Monomoy. Many such changes have been developed in the progress of this important work.

SEA-COAST HYDROGRAPHY AND CURRENTS.

The steamer *Blake*, Lieut. J. E. Pillsbury, U. S. N., commanding, was engaged from July to November making off-shore soundings from Montauk Point to Phelps's Bank, and in making current observations extending from a position to the southward of Nantucket to the coast of New Jersey. These observations added materially to the information in the office in regard to the set of the current in this important locality. Much, however, remains to be done in investigations regarding inshore currents along our coast.

CHESAPEAKE BAY—VICINITY OF CAPE CHARLES.

Owing to the reported changes in the extensive shoal grounds in the vicinity of Cape Charles on the northern side of the entrance to Chesapeake Bay, it was deemed advisable to make a resurvey of the locality. This duty was assigned to Lieut. M. L. Wood, U. S. N., assistant Coast and Geodetic Survey, who was directed in April, 1888, to assume command of the steamer *Endeavor*, then at New York, and organize a hydrographic party on board that vessel. The *Endeavor* left New York April 21, and upon arrival at the working ground the resurvey was begun at once, and was prosecuted vigorously, though much retarded by very unfavorable weather. This work was still in progress at the close of the fiscal year.

NORTH CAROLINA SOUNDS.

The party on board the schooner *Scoresby*, Lieut. Francis Winslow, U. S. N., commanding, was engaged throughout the year upon works connected with an examination of the oyster-beds of the sounds of North Carolina.

ST. SIMON'S SOUND, GEORGIA.

The bar obstructing the entrance to St. Simon's Sound, Georgia, is of a shifting character, and the results of surveys of it can not be depended upon for any length of time. The growing commercial interests of the port of Brunswick, Ga., approached through St. Simon's Sound, render it desirable, however, that the bar be examined occasionally. Accordingly the party on board the *Blake* made a resurvey of this bar in May, 1888, and the results obtained, which show marked changes, are now indicated on the charts.

WEST COAST OF FLORIDA.

The steamer *Bache*, Lieut. J. F. Moser, U. S. N., commanding, having refitted at Baltimore, sailed January 3, 1888, for the Gulf of Mexico, where the hydrographic work on the west coast of Florida was carried on by this party until May 10. The results show a most gratifying success achieved in the face of many adverse conditions. At the end of the fiscal year the *Bache*, having refitted at New Bedford, Mass., had begun work in the vicinity of Martha's Vineyard.

COAST OF LOUISIANA.

The steamer *Gedney*, Lieut. F. H. Crosby, U. S. N., commanding, left New York January 3, 1888, under instructions to continue unfinished hydrography on the coast of Louisiana, and was engaged in this work until June 1. During the greater portion of the season, progress was much retarded by unfavorable weather.

On the way south in January, 1888, an examination of a reported shoal was made off New Inlet, Florida.

HYDROGRAPHY—PACIFIC COAST (COASTS OF OREGON AND WASHINGTON TERRITORY).

The steamer *McArthur*, Lieut. J. C. Burnett, U. S. N., commanding, has been engaged in hydrographic work on the coasts of Oregon and Washington Territory. On September 18, 1887, a whale-boat was capsized while in Shoalwater Bay, Washington Territory, while away from the vessel on duty, resulting in the death of Ensign N. S. Mosely, U. S. N., in charge of the boat. A special report of this distressing occurrence was made at the time. Work was closed in October, 1887, and resumed in April following. This party was still on the working ground at the close of the fiscal year. The prevalence of thick fogs has been a great drawback in the work.

PUGET SOUND AND ADJACENT WATERS.

The schooner *Earnest* has been employed in the survey of the northern waters of Washington Territory. Work for the season of 1887 was closed October 28. Lieut. C. T. Forse, U. S. N., was in command until December 10, 1887, and upon his detachment was succeeded by Lieut. H. T. Mayo, U. S. N. Work was resumed in April, 1888, and was in progress at the close of the fiscal year.

ALASKA EXPLORATIONS.

The steamer *Patterson*, Lieut. Commander C. M. Thomas, U. S. N., commanding, having been thoroughly refitted, left San Francisco for Alaska on the 9th of April, 1888, to carry on the regular work of the Survey in Stephan's Sound and Frederick Passage. In July it became necessary to discontinue this work to take up that of Portland Canal and Pearse's Channel, a survey of this locality having been requested by the Department of State. Lieutenant Commander Thomas was instructed to push this as rapidly as was consistent with accuracy, and to complete it before the end of the season. The reports of this work are most gratifying, showing great skill and energy on the part of the chief of party and his assistants.

In addition to the above mentioned work the following hydrography has been executed by the field officers of the Survey in connection with topography, and turned in for verification:

Off Nausett Beach, Massachusetts, by Assistant H. L. Marindin, Coast and Geodetic Survey.

Inside waters of Delaware, Maryland, and Virginia, by Assistant D. B. Wainwright, Coast and Geodetic Survey.

Mobile River, Alabama, by Subassistant J. Henry Turner, Coast and Geodetic Survey.

Atchafalaya River, Louisiana, by Assistant C. H. Sinclair, Coast and Geodetic Survey.

San Juan, Capistrano Bay, California, Ferdinand Westdahl.

Eel River, California, Ferdinand Westdahl.

Examination of Newport Bay and San Pedro Bay, Ferdinand Westdahl.

In the three last named cases the work was executed under the general direction of Prof. George Davidson, Assistant Coast and Geodetic Survey.

DEEP SEA SOUNDINGS AND OCEAN CURRENTS.

The plan submitted by Lieut. J. E. Pillsbury, U. S. N., for his winter's work having been approved by you, the *Blake*, under his command, started south on the 28th of December, 1887, for the purpose of gauging the currents which enter the Caribbean Sea. During the winter he occupied stations in all the channels between the Windward Islands and extending as far to the westward as Cuba. His very interesting report is already in your possession. The work on which

Lieutenant Pillsbury is engaged is of interest not only to the scientist but of the greatest value to the navigator. It is the most practical and thorough attempt to investigate ocean currents that has ever been made, and the results are most gratifying.

ALASKA COAST PILOT.

The amount of new data available concerning the coast of Alaska rendered the rewriting of the Alaska Coast Pilot desirable, and in compliance with my recommendation to that effect this work was, in November, 1887, placed in the hands of Lieut. Commander H. E. Nichols, U. S. N., Assistant Coast and Geodetic Survey, whose service in Alaskan waters rendered him peculiarly well fitted for this important assignment.

Lieutenant-Commander Nichols has been engaged upon this duty throughout the remaining portion of the fiscal year. Early in the spring of 1888 he visited Alaska in connection with the work, and was still collecting data in that locality at the close of the fiscal year. He has since returned to San Francisco and has submitted an interesting report of his season's work.

COAST PILOT DIVISION.

The Coast Pilot Division has continued under the immediate supervision of Lieut. George H. Peters, U. S. N., Assistant Coast and Geodetic Survey, whose annual report is submitted herewith.

Lieutenant Peters has immediate charge of the Coast Pilot work of the Survey on the Atlantic coast and his duties afloat require him to be absent from the office from time to time. During such periods Ensign E. H. Tillman, U. S. N., has been in charge of the office work of this Division.

Although the force available for compiling Coast Pilot matter, etc., has been materially affected by detachment, and by assignment to other duties, yet there has been no time when the printer has not had in hand the manuscript of one or more volumes, and other manuscript has been prepared and is ready to be put in type when practicable.

Work has been in progress on a large volume, designed to cover the Atlantic Coast of the United States. As stated in the annual report of last year, the plan followed in the work is in conformity with the method of treatment proposed by Lieutenant Peters. In consideration of the time required to issue the entire work in printed form, it has been deemed advisable to prepare and have printed separately such parts of the new work as cover portions of the coast for which a publication of this nature is in most demand. With this in view, the manuscript of the new work covering the coast from Point Judith to the East River inclusive has been sent to the printer, to be issued in one part or volume.

HYDROGRAPHIC DIVISION.

This Division was in charge of Lieut. M. L. Wood, U. S. N., from the beginning of the fiscal year until April 17, 1888. On the latter date Lieutenant Wood was temporarily detached from the office and ordered to command the steamer *Endeavor*.

During the absence of Lieutenant Wood, Lieutenant Peters assumed charge of the Division in addition to his own work, and on the latter's detachment in May for field duty, all this work devolved upon Ensign Tillman, U. S. N.

The duties of the Hydrographic Division are various, numerous, and exacting, consisting in laying out hydrographic work, plotting hydrography, examining and verifying sheets from the field and drawings for photo-lithographs, and in giving notification of newly discovered dangers, changes in hydrography and changes in the aids to navigation, so that the same may be properly shown on the charts at the earliest possible moment and furnished the mariner through the monthly Notice to Mariners.

The report of Lieut. M. L. Wood, U. S. N., in charge of the Division, is forwarded herewith.

REPAIRS OF VESSELS.

During the past fiscal year the vessels of the Survey have been kept in fair condition, and a steam-launch and a sharpie, a small schooner of light draught, have been purchased or built. The latter vessel was built under special instructions from you for use in the inland waters of Florida and Louisiana, where a light draught is absolutely essential.

A second vessel of the same class, sixty feet long and not to draw more than twenty inches with a load of four and a half tons, is now being constructed by the same builder, Mr. A. C. Brown, of Tottenville, N. Y. With these limited dimensions, fairly comfortable quarters for three officers and eight men are obtained, with water and provision capacity for thirty days. I am informed by Mr. B. A. Colonna, Assistant in charge of Office and Topography, who first suggested the building of vessels of this class, that they in every way answer the purpose he had in view in proposing them to you.

The steam-launch referred to above was purchased for use in Puget Sound for three thousand dollars. It was at first the intention to build a boat better adapted to the purpose than anything offered for sale, but the high prices charged for both hull and motive power, together with the loss of time it would incur, rendered this not advisable. When an opportunity occurs, at the end of the summer season, changes in the internal arrangements of this boat can be made, which will better adapt her for hydrographic purposes.

No extensive repairs have been made to any one of the vessels, except possibly to the *Hassler* and *Endeavor*. Neither of these vessels had been used for some time, and consequently a larger sum of money than usual was necessary to put them in proper condition for work.

The stern-wheel steamer *Barataria* and launches Nos. 3, 9, and 16 were sold during the fiscal year, they being old and not worth repairing.

The schooner *Silliman* was found to be in a condition that did not warrant her being repaired, and there was moreover no necessity of retaining her in the Survey, as we have more vessels of this class than are needed. This was by your direction represented to the Navy Department, with the suggestion that she be transferred for experimental purposes should that Department deem it advisable. The offer was accepted and the transfer made, and the *Silliman* was afterwards used in an experimental trial of the dynamite gun.

In April the steamer *Daisy* was by your direction loaned to the New York and New Jersey Boundary Commission for the purpose of replacing the buoys in Raritan Bay and to mark the permanent boundary line between New York and New Jersey.

In May the schooner *Palinurus* was turned over for the summer to the New York Fisheries Commission.

The steam whale-boat No. 21 attached to the schooner *Yukon* was lost in the month of November, having been swamped, owing to the parting of a tow-line while alongside of the *Yukon*.

The Herreshoff Launch No. 13 attached to the party in Vineyard Sound under charge of Lieut. C. P. Perkins, U. S. N., was also lost in September, 1887, while running from No Man's Land to Cuttyhunk for a harbor.

The vessels of the Survey have been kept in fair condition during the past year. While the amount of the appropriation for repairs of vessels is ample for all ordinary overhauling, it will not be sufficient when it becomes necessary to make extended repairs to several of the larger vessels and at the same time to replace any of the steam-launches.

The repairs to the *Gedney* necessary to place her in condition for passage to San Francisco, sheathing and other repairs to the *Blake*, and a general overhauling of the *Endeavor* to place her in proper shape to take the *Gedney's* place in the Gulf, will exhaust so much of the repair fund as to render it difficult to keep the other vessels running during the fiscal year. It is important that the *McArthur* should be supplied with a new boiler at an early date, but this will be impossible during the present fiscal year (1888–1889) unless special appropriation is made.

The clerical work in this office was performed by Mr. George J. Vestner, Mr. R. E. King, and Mr. W. H. Lanman until January 9, 1888, when Mr. J. H. Roeth was assigned to this duty. This work, which is laborious and exacting, has during the year been satisfactorily performed by these gentlemen.

In conclusion I would say that the inshore hydrography of the coast of Maine is, at this date, October, 1888, completed. The survey of Vineyard Sound will be completed next year, thus finishing the resurvey of that important thoroughfare from New York to Boston.

The survey of the latter harbor should be taken up at an early date, as the chart at present in use is not what it should be for so important a place. The hydrography was executed in 1861–1864 under the direction of the Harbor Commissioners of the State of Massachusetts, so that the Survey has no work of its own to place before the public.

The original hydrographic survey of the Atlantic coast is practically completed, but examination and resurveys of our sand-bar harbors will be constantly required.

The plan of dividing the coast into districts and having a vessel of the Survey fully equipped assigned to each district to gain all possible information necessary to keep charts up to date has frequently been a subject of discussion between us.

The hydrographic survey in the Gulf is nearly completed; two years should end it with average season's work.

In the Pacific the work is not so far advanced, owing to short appropriations, insufficient number of vessels, and a very difficult coast to work on. From these and other causes, notably among them, fogs, the work has necessarily been slow. I am of the opinion that it will take from four to six years to complete the development of the fifty-fathom curve from San Diego to Puget Sound.

The survey of Alaska, one of great importance, has been very rapidly advanced during the past year. The present scheme embraces only the usual inside steamer route to Sitka, but the increasing commerce, due to the country's great natural advantages in the way of minerals, timber, and fish, seems to demand that the survey of this important territory be extended to the outside coast as far as the Aleutian Islands and eventually to Bering Strait.

Very respectfully,

W. H. BROWNSON,
Lieutenant Commander U. S. Navy, Hydrographic Inspector.

Mr. F. M. THORN,
Superintendent Coast and Geodetic Survey, Washington D. C.

REPORT OF THE COAST PILOT DIVISION FOR THE FISCAL YEAR ENDING JUNE 30, 1888.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, October 19, 1888.

SIR: I have the honor to submit the following report covering the work of the Coast Pilot Division during the fiscal year ending June 30, 1888. Under the general direction of the Hydrographic Inspector the duties of this Division involve the execution of work both at the office and in the field.

At the beginning of the year the first edition of Subdivision 21, and new editions of Subdivisions 6, 7, and 9 of the Atlantic Local Coast Pilot were in the hands of the printer. Subdivision 21 has been put through the press and published. The new (third) edition of Subdivisions 6, and 7, in one volume, was in press at the close of the year and will soon be published. The manuscript of the new edition of Subdivision 9 has been returned, with the request that any alterations rendered necessary by change in aids to navigation, etc., since its preparation may be made in the manuscript, and this work is now in hand.

A new Coast Pilot volume covering the coast from Point Judith to the East River was practically completed at the close of the fiscal year and has since been sent to the printer, under the title "U. S. Coast Pilot—Atlantic Coast, Part IV—Long Island Sound, with approaches and adjacent waters." This volume was prepared as part of the large volume, now in preparation, which is designed to embrace the Atlantic Coast of the United States. The plan followed is in conformity with the method of treatment proposed by me for Coast Pilot work, the adoption of this method having been authorized by the Superintendent. Part IV is to be issued separately to meet the demand for a Coast Pilot publication covering the section of the coast included therein.

The manuscript for the first edition of the Atlantic Local Coast Pilot, Subdivision 22, Straits of Florida, has been prepared and is ready for the printer.

Much work has been done in connection with the preparation of the large volume designed to cover the Atlantic Coast. A great part of the manuscript for the coast of Maine is practically ready for the printer. Much of the new work on the coast of Massachusetts has been incorporated in the new edition of Subdivisions 6 and 7 of the old Local Coast Pilot series. For Nantucket and Vineyard Sounds the field-work has been done, and a considerable part of the office work. Buzzard's and Narragansett Bays have received nearly all the attention that will be necessary. A part of the new large volume embracing the coast from Point Judith to the East River is now in the hands of the printer to be published as a special issue, as already stated. Nearly all of the manuscript for New York Bay and Harbor and the adjacent waters has been prepared, as has that for the coast of New Jersey. In Delaware Bay and River but little has been done; the field-work is still to be taken up. Much work was accomplished in connection with Chesapeake Bay and tributaries, which it was intended to include in a separate small volume. This has not yet been done, owing to the many delays in printing new editions of volumes already on the catalogue but out of print. Considerable revision will now be necessary for the Chesapeake, and this is now in hand. Work is also in progress on the shore from Cape Henry to Key West, which can soon be put in shape, as it will probably be covered by less than eighty pages of printed matter.

Excellent results are still obtained by the use, when desirable, of the general form of interrogatories devised with the view of obtaining directly from the best local sources, special information concerning our ports and harbors. Great courtesy has been shown by local authorities in furnishing information desired.

The field-work of collection, revision, and verification of data, has been carried on from time to time as necessary under special instructions, and reports covering such work have already been made. From the beginning of the fiscal year until in October I had command of the *Endeavor*, engaged in work of this nature on the Eastern coast and especially on the coast of Maine. Ensign William J. Maxwell and Mr. John Ross were with me on board the *Endeavor*, Ensign E. H. Tillman being the only one of the Coast Pilot force at the Office during this period. The members of the party were detached from the *Endeavor* October 20, 1887, and resumed duties at the Office. The results obtained while afloat have given a large amount of matter, now in manuscript, much of which is practically in shape for publication.

After April 18, 1888, the charge of the Hydrographic Division devolved on me and required a large share of my personal attention until I again took up field duties, assuming command of the steamer *Daisy*, May 31, 1888, for Coast Pilot work in Nantucket and Vineyard Sounds and Buzzard's Bay. I was accompanied by Mr. Ross while engaged on this work, which was not quite completed at the close of the fiscal year.

Ensign William J. Maxwell, U. S. N., was detached from the Survey November 20, 1887. He is an officer of excellent judgment and is zealous and industrious. I consider myself fortunate in having had his valuable assistance. Ensign Edwin H. Tillman, U. S. N., and Mr. John Ross have rendered most efficient services in connection with the Coast Pilot work throughout the year. After my departure for field-work in May, 1888, Mr. Tillman had immediate charge of the details of Office work of both the Coast Pilot and Hydrographic Divisions, the duties of the latter necessarily occupying the greater part of his time. Miss Glova B. Bower was temporarily assigned to duty in the Coast Pilot Division as a copyist, in April, 1888, and by instructions of the Superintendent was employed in that capacity as a part of the regular force of the Division from May 1, 1888. Miss Bower performed her duties to my satisfaction.

Very respectfully,

GEORGE H. PETERS,
Lieutenant U. S. N., Assistant Coast and Geodetic Survey,
Chief of Coast Pilot Division.

Lieut. Commander W. H. BROWNSON, U. S. N.,
Hydrographic Inspector, Coast and Geodetic Survey,
Washington, D. C.

REPORT OF THE HYDROGRAPHIC DIVISION FOR THE YEAR ENDING JUNE 30, 1888.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, D. C., October 4, 1888.

SIR: I have the honor to submit the following report of the work performed by the Hydrographic Division during the fiscal year ending June 30, 1888.

On April 17, 1888, I was temporarily detached and ordered to take charge of a Hydrographic party on board the steamer *Endeavor*. During my absence Lieut. G. H. Peters, U. S. N., had charge of the division until May 31, when he was ordered to field duty, and Ensign E. H. Tillman, U S. N., was left in charge until the close of the fiscal year.

The draughtsmen assigned to regular duty in the Hydrographic Division are: Eugene Willenbücher, W. C. Willenbücher, F. C. Donn, and E. H. Wyvill, the latter from December 10, 1888.

As noticed in my last report, there has been an increase during the last few years in the amount of data from hydrographic parties passing through this Division in the office. This amount has probably reached its maximum and can be attended to by the force on hand.

Hydrographic statistics for fiscal years 1886–1888, *inclusive.*

Fiscal year ending June 30—	Number of—					
	Sheets.	Volumes.	Angles.	Soundings.	Miles run.	Square miles.
1886	63	377	117, 588	567, 968	14, 932	8, 701
1887	74	470	134, 301	661, 682	17, 557	11, 285
1888	67	373	130, 677	609, 903	19, 912	11, 875

There will always be a necessity for having the records of work done by hydrographic parties in the field plotted, drawn, and verified in this Division as rapidly as possible, so that intelligent decisions can be reached as to the data required for immediate use in correcting charts already published or in process of construction.

I call your attention to a reduction in the number of corrections required to be made on proofs and copies of charts owing to changes in the routine, and the consequent reduction in the number of corrections required to be made by hand on copies of charts issued from this office.

During the past few years, owing to the increase in the number of sources of information, correcting charts to date of sending from the Office had become a task; and as these corrections relating to hydrography emanated from this Division and had to be indicated on proofs for the information of other Divisions in the Office, the labor required in this Division alone was quite an item, and the application of these corrections to printed copies on the shelves of the chart-room was a severe labor which necessarily interfered with the rapid filling of requisitions.

To reduce labor both in this Division and in the chart-room, a change has been made in the system of supplying corrections and in correcting copies of charts to be issued. In consequence a material reduction has been made in the liability to error in supplying corrections to date and also in the number of corrections to be applied by hand, and the accuracy of Coast and Geodetic Survey charts issued for all purposes materially increased.

The care and labor formerly expended in applying hand corrections to proofs and copies is now applied in a different form with more gratifying results. At present it can be safely said that the charts of the Coast and Geodetic Survey are practically corrected from all information received at the Office to date of issue from the chart-room.

The date of printing and the date of issue from chart-room now indicate the limit of the office indorsement; and the increasing demand for the charts of the Survey on the part of the sea-faring community shows an appreciation of the improvements made in keeping important changes indicated to as late a date as possible.

Notes of corrections for charts have heretofore been issued quarterly in a "Notice to Mariners," until during the past year, when the issue has been monthly instead of quarterly, with satisfactory results in simplifying work in the Division and in giving earlier information of important changes to those using charts.

The time required for issuing "Notices to Mariners" from the date of sending the copy to the date of mailing the printed notice has been reduced to about six or seven days, which seems about as short as it can be made under the present routine of printing in a different part of the city, in an office where the work loses its turn of precedence on account of the time necessarily taken up in conveying proofs backward and forward.

It is possible that arrangements could be made for this printing to be done in this building, and it is certain that a change could be effected that would result in economy to the Government and shorten the time now required to publish a "Notice to Mariners."

These monthly notices of chart corrections are intended to assist masters of vessels and other users of charts in keeping working copies up to date and also as a practical indorsement of those requiring no corrections.

The data contained is compiled with great care from the records of this Division, of which they are partial abstracts.

Nearly all letters relating to the routine work of the Division have been prepared for your signature.

The duties of the Division are so complex that it is difficult to mention the actual work done by each draughtsman, as allowances have to be made for each individual sheet that is plotted, owing to the particular circumstances under which the hydrographic survey was made.

The draughtsmen have been employed as outlined in my report of last year, with the exception that to Mr. E. H. Wyvill the greater part of miscellaneous work was assigned.

Where every one has done his best and responded promptly to every call, individual mention is useless.

The following is a statement of the work performed:

Original hydrographic sheets plotted, verified, and inked during the fiscal year ending June 30, 1888.

Title of sheet.	Scale.	Draughtsman.	Remarks.
ATLANTIC COAST.			
Off Nausett Beach, Massachusetts, sheet No. 1	1-10000	W. C. Willenbucher	Plotted and drawn.
Off Nausett Beach, Massachusetts, sheet No. 2	1-10000	do	Do.
Off-shore soundings, Montauk Point to Phelps Bank	1-300000	do	Do.
Edgartown Harbor, Massachusetts	1-10000	do	Do.
Vineyard Sound, Cape Poge to West Chop	1-10000	do	Do.
Vineyard Sound, entrance and southern approaches	1-20000	E. Willenbucher	Do.
Approaches to Vineyard Sound and Buzzard's Bay	1-40000	do	Do.
Approaches to Narragansett Bay, Block Island Sound	1-40000	do	Do.
Coast of Massachusetts, from Black Rock to Tunipus Beach	1-10000	W. C. Willenbucher	Do.
Coast of Rhode Island, from Tunipus Beach to Sachuest Point	1-10000	E. Willenbucher	Do.
Coast of Rhode Island, from Sachuest Point to Brenton's Point	1-10000	do	Do.
Coast of Rhode Island, from Brenton's Point to Point Judith	1-10000	W. C. Willenbucher	Do.
Experimental lines, New York Lower Bay, sheet No. 1	1-10000	do	Protracted, plotted, and drawn.
Experimental lines, New York Lower Bay, sheet No. 2	1-10000	do	Do.
Experimental lines, New York Lower Bay, sheet No. 3	1-10000	F. C. Donn	Do.
Experimental lines, New York Lower Bay, sheet No. 4	1-10000	do	Do.
Off Sandy Hook, New York Lower Bay	1-20000	E. Willenbucher	Plotted and drawn.
Raritan Bay, New York and New Jersey	1-20000	do	Do.
The Narrows, New York Bay	1-5000	do	Do.
Arthur Kill, Woodbridge to Fresh Kill	1-5000	do	Do.
Arthur Kill, Fresh Kill to Dividing Creek	1-5000	do	Do.
Staten Island Sound and lower part of Newark Bay	1-5000	do	Do.
Newark Bay	1-10000	do	Protracted, plotted, and drawn.
Examination of inner bar, Gedney Channel	1-10000	W. C. Willenbucher	Plotted and drawn.
Inside waters, Delaware and Maryland, Miller's Creek to Sinepuxent Bay.	1-20000	do	Do.
Chincoteague Bay, upper part, Maryland	1-20000	do	Do.
Chincoteague Inlet, Virginia	1-20000	do	Protracted, plotted, and drawn.
Inside waters of Virginia, Watt's Bay to Floyd's Bay	1-20000	do	Plotted and drawn.
West coast of Florida, south of Cape Romano, sheet No. 2	1-40000	E. Willenbucher	Do.
West coast of Florida, south of Cape Romano, sheet No. 1	1-40000	do	Do.

Original hydrographic sheets plotted, verified, and inked, etc.—Continued.

Title of sheet.	Scale.	Draughtsman.	Remarks.
ATLANTIC COAST—continued.			
West coast of Florida, Chassahowitzka River to Crystal River	1-40000	E. Willenbucher	Plotted and drawn.
Examination of middle ground, Cedar Keys	1-10000	do	Do.
Examination of outer bar, Cedar Keys, Florida	1-10000	do	Do.
Mobile River, sheet No. 1	1-5000	W. C. Willenbucher	Do.
Mobile River, sheet No. 2	1-5000	F. C. Donn	Do.
Mobile River, sheet No. 3	1-5000	E. Willenbucher	Protracted, plotted, and drawn.
Mobile River, sheet No. 4	1-5000	do	Plotted and drawn.
Mobile River, sheet No. 5	1-5000	F. C. Donn	Do.
Mobile River, sheet No. 6	1-5000	E. H. Wyvill	Do.
Mobile River, sheet No. 7	1-5000	W. C. Willenbucher	Protracted, plotted, and drawn.
Mobile River, sheet No. 8	1-5000	E. Willenbucher	Do.
Mobile River, sheet No. 9	1-5000	W. C. Willenbucher	Do.
Off coast of Louisiana, Southwest Pass to longitude 89° 35′	1-40000	do	Plotted and drawn.
Off coast of Louisiana, longitude 89° 35′ to Barataria Bay	1-40000	do	Do.
Cote Blanche Bay, Louisiana	1-20000	do	Do.
Atchafalaya Bay, dredged channel, sheet No. 1	1-10000	do	Do.
Atchafalaya Bay, dredged channel, sheet No. 2	1-10000	do	Do.
Off coast Louisiana	1-80000	F. C. Donn	Do.
Vermillion Bay, sheet No. 1	1-20000	do	Do.
PACIFIC COAST.			
San Pablo Bay, California	1-20000	do	Do.
Karquines Strait, California	1-10000	do	Verified, inked, and finished.
Suisun Bay, Suisun Point to Stephenson Point	1-10000	do	Do.
Suison Bay, Stephenson's Point to York Point	1-10000	do	Plotted and drawn.
Coast of California, White Rock to Wyman △	1-20000	do	Verified, inked, and finished.
Coast of California, Wyman △ to Punta Gorda	1-20000	do	Do.
Coast of California, Punta Gorda to Mendocino	1-20000	do	Do.
Umpquah River, Oregon entrance	1-10000	W. C. Willenbucher	Plotted and drawn.
Umpquah River, Oregon entrance	1-10000	do	Do.
Off-shore hydrography, vicinity of Tillamook Bay	1-40000	do	Protracted, plotted, and drawn.
Tillamook Bay entrance (examination)	1-10000	do	Do.
Shoalwater Bay entrance, Washington Territory	1-20000	F. C. Donn	Plotted and drawn.
Between Shoalwater Bay and Gray's Harbor	1-40000	do	Do.
Admiralty Inlet, Puget Sound, Washington Territory	1-20000	do	Verified, inked, and finished.
Possession Sound, Washington Territory	1-20000	do	Do.
Port Suisun, Washington Territory	1-20000	do	Do.
Rosario Strait and Bellingham Bay	1-20000	do	Do.
Padilla Bay, Washington Territory	1-20000	do	Do.
ALASKA.			
Frederick Sound and Harbors (five sheets), Southeast Alaska	Various.	E. Willenbucher	Verified, corrected, and finished.
Duncan Canal, Southeast Alaska, three sheets	1-10000	do	Do.
Harbors in Clarence and Sumner Straits, Southeast Alaska, eleven sheets.	Various.	do	Do.
EXAMINATIONS, ETC.			
Additional hydrography for four sheets	Various.	W. C. Willenbucher	Protracted, plotted, and drawn.
Additional hydrography for two sheets	Various.	E. Willenbucher	Do.

Synopsis from the records of the hydrographic sheets plotted and drawn during the fiscal year ending June 30, 1888.

Name of draughtsman.	Number of—					
	Sheets.	Volumes.	Angles.	Soundings.	Miles.	Deep-sea soundings
Eugene Willenbucher	*22	166	56,603	273,024	9,167	....
W. C. Willenbucher	25	105	25,768	179,721	4,900¾	....
F. C. Donn	20	139	62,850	206,197	5,912¾	....
E. H. Wyvill	1	1	331	1,278	14	....
	67	411	145,552	660,220	19,994½	....

* Does not include eighteen harbor sheets of Southeast Alaska verified, corrected, and finished by Eugene Willenbucher.

Verification, revision, and correction of reduced drawings of hydrography for fiscal year ending June 30, 1888.

Catalogue number of chart.	Title of chart.	Scale.	Draughtsman.
7	Cape Ann to Gay Head, additional hydrography	1-400000	E. Willenbucher.
8-*a*	Approaches to New York, new edition	1-400000	Do.
9	Cape May to Cape Henry, new edition	1-400000	Do.
12	Cape Romain to St. Mary's River entrance	1-400000	Do.
	Approaches to New York and Long Island Sound	Mercator projection.	Do.
101-*a*	Quoddy Head to Head Harbor Island	1-80000	Do.
106	Kennebec entrance to Saco River, additions	1-80000	W. C. Willenbucher.
111	Monomoy to Nantucket Shoals, additions	1-80000	E. Willenbucher.
114	Eastern part of Long Island Sound, drawing	1-80000	Do.
114-*a*	Eastern part of Long Island Sound, proof	1-80000	W. C. Willenbucher.
115	Long Island Sound, middle part, new	1-80000	E. Willenbucher.
116	Long Island Sound, western part, new	1-80000	Do.
123	Absecon Inlet to Cape May, new	1-80000	Do.
125	Delaware Bay and River, middle sheet, new	1-80000	Do.
126	Delaware Bay and River, upper sheet, new	1-80000	Do.
127	Cape May to Isle of Wight, additional hydrography	1-80000	Do.
128	Isle of Wight to Chincoteague Inlet, addition	1-80000	Do.
129	Chincoteague Inlet to Hog Island, additions	1-80000	Do.
136	Chesapeake Bay, upper sheet, additions	1-80000	Do.
150	Masonboro Inlet to Shallotte Inlet, including Cape Fear	1-80000	Do.
178	Hog Island to Wall's Creek	1-80000	Do.
207	Matagorda Bay, additions	1-80000	W. C. Willenbucher.
208	Pass Cavallo, Lavaca, and San Antonio Bays, additions	1-80000	Do.
209	Aransas Pass, Aransas and Copano Bays, additions	1-80000	Do.
210	Aransas Pass and Corpus Christi Bay, additions	1-80000	Do.
211	Padre Island, latitude 27° 12′ to latitude 26° 33′, additions	1-80000	E. Willenbucher.
212	Latitude 26° 33′ to Rio Grande, additions	1-80000	W. C. Willenbucher.
303	Coast of Maine	1-40000	E. Willenbucher.
311	Penobscot River and Belfast Bay additions	1-40000	W. C. Willenbucher.
225	Portland Harbor, additions	1-20000	Do.
337	Boston Harbor, additions	1-40000	E. Willenbucher.
361-2	Harbor of Beaufort, Sachem's Head	1-10000	Do.
361-3	Entrance to Norwalk and Saugatuck Rivers, etc	1-10000	Do.
361-4	Port Jefferson	1-10000	Do.
361-5	Long Island Sound, Throg's Neck to Davenport Island	1-10000	Do.
304-2	Block Island	1-10000	Do.
367	Oyster Bay	1-30000	Do.
369	New York Bay and Harbor, new edition	1-40000	Do.
369-6	East River, Lawrence Point to Throg's Neck	1-10000	Do.
369-7	Hudson River and Spuyten Duyvil Creek	1-5000	Do.
369-8	Hudson River, Fifty-third street to Fort Washington	1-10000	W. C. Willenbucher.
370	Hudson River, New York to Haverstraw	1-60000	Do.
384	Baltimore Harbor	1-60000	E. Willenbucher.
420	Beaufort Harbor, N. C	1-40000	Do.
424	Cape Fear River entrance	1-40000	Do.
425	Cape Fear River, Federal Point to Wilmington	1-40000	Do.
520	Galveston Harbor	1-40000	Do.
516	Atchafalaya Bay (dredged channel)	1-50000	W. C. Willenbucher.
606	San Diego Bay	1-40000	F. C. Donn.
	San Juan Capistrano Bay	1-10000	E. Willenbucher.
610	San Pedro Bay	1-40000	F. C. Donn.
610	Wilmington and San Pedro Harbor	1-40000	W. C. Willenbucher.
638	Umpquah River	1-20000	E. Willenbucher.
639	Siuslaw River entrance	1-10000	Do.
640	Columbia River entrance to Astoria	1-40000	Do.
641-*b*	Columbia River, Grim's Sound to Kalama	1-40000	Do.
681-*a*	Columbia River approaches	1-20000	F. C. Donn.
684	Sea-coast and interior harbors of Washington Territory	1-300000	Do.
685	Admiralty Inlet, Puget Sound	1-80000	E. Willenbucher.
706	Sumner Strait, Alaska	1-20000	Do.
960	Alaska and adjoining territory	1-300000	F. C. Donn.

Miscellaneous draughting done during the fiscal year ending June 30, 1888.

Description.	Draughtsman.
Reducing hydrography of Masonboro Inlet and vicinity for Coast Chart No. 150	E. Willenbucher.
Reducing new hydrography of Oyster Bay to scale 1-30000, for comparison	Do.
Reducing additional hydrography for Coast Chart No. 123	Do.
Reducing Coaster's Island Harbor for chart 253-2	Do.
Reducing inshore hydrography for Coast Chart No. 211	Do.
Reducing additional soundings for Coast Chart No. 127	W. C. Willenbucher.
Working out projects for fifteen charts covering the surveys in S. E. Alaska by Thomas in 1887, and Snow and Helm in 1886.	E. Willenbucher.
Enlarging hydrography around Point Judith	W. C. Willenbucher.
Rough reduction of engineer's survey of Pass Cavallo, for 522-*a*	Do.
Correcting four-fathom curve on new Coast Chart No. 124	E. Willenbucher.
Re-adjustment of reduced hydrography for Coast Charts Nos. 115 and 116, new	Do.
Overhauling Mercator Chart of Long Island Sound for names	Do.
Overhauling all first and second proofs of photolithographic charts	W. C. Willenbucher.
Overhauling final proof of new Coast Chart No. 124	Do.
Drawing curves on charts at Baltimore Harbor, etc	Do.
Furnishing additional topographic data for four projections for hydrographic parties	Do.
Indicating on proof where hydrography is needed	Do.
Comparing numerous charts of different scales	Do.
Plotting aids to navigation on numerous charts	Do.
Correction of numerous charts for file, Engraving Division and Chart Room	Do.
Correcting manuscripts and reading proof of monthly Notice to Mariners	Do.
Laying out schemes for projections and duplicating same	Do.
Laying out scheme for new charts of Delaware River	Do.
Registering and arranging for file all hydrographic records received	Do.
Furnishing statistics, tabulated statements, etc., for Annual Report	Do.
Keeping up hydrographic Progress Sketches	Do.
Investigating tides of Columbia River and other places	Do.
Verification of projections for field parties	Do.
Making nineteen tracings for field and office use	Do.
Correcting and lettering eight blue prints of Coast Chart No. 101-*a*	Do.
Correcting and lettering four blue prints of Sumner Strait	Do.
Gulf Stream curves, copying curves and lettering	F. C. Donn.
Gulf Stream current stations, locating and plotting	Do.
Gulf Stream records, examining records for anchorage	Do.
Off-shore currents, Sandy Hook, plotting position of station	Do.
Verifying and correcting sixteen different charts for file, Engraving Division	Do.

Very respectfully,

M. L. WOOD,
Lieutenant U. S. N., in charge Hydrographic Division.

Lieut. Commander W. H. BROWNSON, U. S. N.,
Inspector of Hydrograghy, Coast and Geodetic Survey.

Names of vessels, their tonnage, etc., in the service of the Coast and Geodetic Survey during the fiscal year ending June 30, 1888.

No.	Name of Vessel.	Tonnage.	Complement of— Officers.	Men.
1	Steamer Patterson	453	12	44
2	Steamer Hassler	243	10	34
3	Steamer Blake	218	10	37
4	Steamer Bache	186	10	37
5	Steamer Gedney	133	8	26
6	Steamer McArthur	112	7	29
7	Steamer Endeavor	105	7	19
8	Steamer Hitchcock	83	5	14
9	Steamer Arago	38	5	2
10	Steamer Daisy	44	3	11
11	Steamer Cosmos	25	2	5
1	Schooner Eagre	202	6	22
2	Schooner Drift	87	5	14
3	Schooner Earnest	80	5	14
4	Schooner Ready	80	5	14
5	Schooner Yukon	78	6	14
6	Schooner Palinurus	76	5	14
7	Schooner Scoresby	72	5	14
8	Schooner Matchless	....	5	14
9	Schooner Quick	38	4	12
10	Schooner Spy	....	3	8
1	Barge Beauty	28	....	1

RECAPITULATION.

Whole number of vessels:	
Steamers	11
Schooners	10
Barge	1
Total	22
Number of vessels in active service	17
Average number of naval officers for the year	56
Average number of men for the year	268

The complements above given do not represent the actual number of officers or men in the Survey during the year, owing to the fact that some vessels were employed only a part of the time.

List of Naval Officers attached to the Coast and Geodetic Survey during the fiscal year ending June 30, 1888.

Name.	Date attached.	Date detached.	Remarks.
LIEUTENANT-COMMANDERS.			
C. M. Thomas	Jan. 20, 1887		Still in service.
W. H. Brownson	*Aug. 11, 1881		Do.
H. E. Nichols	Nov. — 1887		Do.
LIEUTENANTS.			
H. B. Mansfield	May 15, 1888		Still in service.
J. E. Pillsbury	July 13, 1882		Do.
J. F. Moser	Jan. 29, 1884		Do.
Charles T. Forse	July 7, 1884	Dec. 10, 1887	
Gharles P. Perkins	Apr. 27, 1886	Feb. 28, 1888	
S. C. Paine	May 1, 1888		Do.
D. D. V. Stuart	July 10, 1885	July 23, 1887	
Francis Winslow	Nov. 12, 1886		Do.
F. H. Crosby	Oct. 6, 1884		Do.
J. C. Burnett	Mar. 23, 1886		Do.
George H. Peters	June 30, 1885		Do.
David Peacock	Mar. 29, 1886	Feb. 14, 1888	
LIEUTENANTS, JUNIOR GRADE.			
M. L. Wood	Apr. 21, 1887		Still in service.
George M. Stoney	May 16, 1888		Do.
H. T. Mayo	May 7, 1886		Do.
Charles A. Gove	Apr. 9, 1888		Do.
Dewitt Coffman	Apr. 12, 1886	Nov. 14, 1887	
E. E. Wright	Apr. 7, 1886	Oct. 20, 1887	
A. W. Dodd	Apr. 9, 1885	Dec. 21, 1887	
ENSIGNS.			
H. W. Harrison	May 2, 1887	Oct. 20, 1887	
W. M. Constant	Mar. 19, 1888		Still in service.
J. H. Oliver	July 21, 1887		Do.
N. J. L. T. Halpine	May 2, 1887		Do.
A. N. Wood	Mar. 17, 1887		Do.
Edward Lloyd, jr	Mar. 18, 1888		Do.
R. M. Hughes	Jan. 13, 1886		Do.
A. G. Rogers	Feb. 10, 1883		Do.
W. P. White	Feb. 10, 1883	July 24, 1887	
J. H. Shipley	Apr. 7, 1885	Sept. 9, 1887	
B. C. Dent	Mar. 17, 1887	Aug. 19, 1887	
A. C. Almy	Sept. 16, 1887		Do.
L. M. Garrett	May 16, 1888		Do.
C. C. Marsh	May 3, 1884	Nov. 21, 1887	
J. A. Bell	Feb 22, 1885		Do.
E. H. Tillman	Dec. 28, 1886		Do.
J. L. Purcell	Mar. 26, 1886	July 11, 1887	
M. L. Read	Apr. 27, 1887	Mar. 24, 1888	
R. O. Bitler	Apr. 29, 1885		Do.
A. P. Niblack	July 2, 1884	Nov. 30, 1887	
J. C. Drake	Apr. 16, 1886		Do.
W. J. Maxwell	Sept. 1, 1886	Nov. 20, 1887	
Franklin Swift	Oct. 30, 1886		Do.
ENSIGNS—continued.			
Spencer Wood	Mar. 17, 1888		Still in service.
W. B. Fletcher	May 17, 1886	May 17, 1887	
Marbury Johnston	May 19, 1886	Nov. 17, 1887	
W. R. M. Field	May 19, 1888		Do.
E. A. Anderson	Apr. 24, 1888		Do.
Harry A. Field	Aug. 1, 1885	Nov. 14, 1887	
A. M. Beecher	Aug. 16, 1886		Do.
F. K. Hill	Mar. 31, 1888		Do.
N. S. Moseley	†Aug. 23, 1886		
Walter O. Hulme	July 12, 1886		Do.
J. D. McDonald	Aug. 10, 1886		Do.
H. E. Parmenter	July 14, 1886	Nov. 14, 1887	
I. K. Seymour	July 22, 1886	Nov. 3, 1887	
G. R. Slocum	Aug. 7, 1887		Do.
J. P. McGuinness	Aug. 9, 1887		Do.
Joseph Strauss	July 16, 1887		Do.
C. S. Stanworth	July 15, 1887		Do.
R. L. Russell	July 25, 1887		Do.
H. A. Bispham	July 13, 1887		Do.
G. R. Evans	July 12, 1887		Do.
J. E. Shindel	July 13, 1887		Do.
D. S. Nes	Sept. 13, 1887		Do.
SURGEON.			
T. H. Streets	May 19, 1884	Oct. 30, 1887	
PASSED ASSISTANT SURGEONS.			
F. B. Stephenson	Sept. 1, 1884	Oct. 28, 1887	
D. O. Lewis	Nov. 28, 1885		Still in service.
Robert Whiting	Mar. 17, 1888		Do.
A. A. Austin	Sept. 22, 1885		Do.
John M. Steele	Mar. 30, 1888		Do.
C. W. Deane	Mar. 27, 1888		Do.
W. H. Rush	June 3, 1884	Oct. 21, 1887	
ASSISTANT SURGEONS.			
Ernst W. Anzal	Jan. — 1887	Mar. 27, 1888	
T. A. Berryhill	Oct. 21, 1887		Still in service.
E. P. Stone	Oct. 29, 1887	Mar. 27, 1888	
PASSED ASSISTANT PAYMASTER.			
J. N. Speel	Dec. 20, 1886		Still in service.
PASSED ASSISTANT ENGINEERS.			
H. N. Stevenson	Mar. 10, 1883	Nov. 17, 1887	
George Cowie, jr	Jan. 1, 1885		Still in service.
George D. Strickland	Sept. 17, 1886		Do.
W. B. Dunning	Nov. 15, 1887		Do.
ASSISTANT ENGINEERS.			
Robert I. Reid	June 9, 1882	Oct. — 1887	
Samuel H. Leonard, jr.	Dec. 21, 1886		Still in service.

* Re-attached January 29, 1885.

† Died September 18, 1887.

List of Naval Officers attached to the Coast and Geodetic Survey, etc.—Continued.

RECAPITULATION.

Lieutenant-Commanders	3
Lieutenants	12
Lieutenants (junior grade)	7
Ensigns	45
Surgeon	1
Passed Assistant Surgeons	7
Assistant Surgeons	3
Passed Assistant Paymaster	1
Passed Assistant Engineers	4
Assistant Engineers	2
	85

NOTE.—From the statement immediately following, it appears that of the eighty-five officers above named, fifty-six were on duty in the Survey at the close of the fiscal year.

List of Naval Officers attached to the Coast and Geodetic Survey, June 30, 1888.

COAST AND GEODETIC SURVEY OFFICE.

Lieut. Commander W. H. Brownson, Hydrographic Inspector.
Lieut. Commander H. E. Nichols, Alaska Coast Pilot.
Lieut. George H. Peters, Coast Pilot Division.
Ensign, E. H. Tillman, Hydrographic Division.
Passed Assistant Paymaster J. N. Speel in charge naval pay accounts.

ATLANTIC AND GULF COASTS.

Steamer Blake (Atlantic Coast).—Lieut. J. E. Pillsbury, Commanding; Ensigns N. J. L. T. Halpine, J. E. Shindel, R. M. Hughes, A. G. Rogers, and C. S. Stanworth; Passed Assistant Surgeon J. A. Berryhill; Passed Assistant Engineer George Cowie, jr.

Steamer Bache (Atlantic Coast).—Lieut. J. F. Moser, Commanding; Ensigns W. O. Hulme and H. A. Bispham; Passed Assistant Surgeon John M. Steele; Passed Assistant Engineer Samuel H. Leonard, jr.

Schooner Eagre (Atlantic Coast).—Lieut. Sumner C. Paine, Commanding; Ensigns L. M. Garrett, W. R. M. Field, and G. R. Evans.

Steamer Daisy (Atlantic Coast).—Ensign Franklin Swift, Commanding.

Steamer Endeavor (Atlantic Coast).—Lieut. M. L. Wood, Commanding; Ensigns W. M. Constant, Edward Lloyd, jr., and E. A. Anderson.

Steamer Gedney (Atlantic Coast).—Lieut. F. H. Crosby, Commanding; Ensigns R. O. Bitler, Jos. Strauss, and D. S. Nes; Passed Assistant Surgeon A. A. Austin.

Schooner Scoresby (Atlantic Coast).—Lieut. Francis Winslow, Commanding; Ensigns J. C. Drake and R. L. Russell.

PACIFIC COAST.

Steamer Patterson (Coast of Alaska).—Lieut. Commander C. M. Thomas, Commanding; Ensigns J. H. Oliver, A. N. Wood, Spencer Wood, A. M. Beecher, J. D. McDonald, and G. R. Slocum; Passed Assistant Surgeon Robert Whiting.

Steamer McArthur (Coasts of Oregon and Washington Territory).—Lieut. J. C. Burnett, Commanding; Lieut. Charles A. Gove; Ensigns F. K. Hill, J. A. Bell, and J. P. McGuinness; Passed Assistant Surgeon C. W. Deane; Passed Assistant Engineer W. B. Dunning.

Steamer Hassler (Coasts of California).—Lieut. H. B. Mansfield, Commanding; Lieut. George M. Stoney; Passed Assistant Surgeon D. O. Lewis; Passed Assistant Engineer George D. Strickland.

Schooner Earnest (Coast of Washington Territory).—Lieut. H. T. Mayo, Commanding; Ensign A. C. Almy.

Number of Naval Officers attached to the Coast and Geodetic Survey vessels during the fiscal year ending June 30, 1888.

Name of vessel.	September 30, 1887.	March 19, 1888.	Name of vessel.	September 30, 1887.	March 19, 1888.
Steamer Blake	8	8	Steamer McArthur	7	6
Steamer Bache	8	7	Steamer Patterson	10	8
Schooner Eagre	7	....	Schooner Scoresby	3	3
Schooner Earnest	3	2	Coast Survey Office	4	6
Steamer Endeavor	2	2	Total	62	49
Steamer Gedney	7	5			
Steamer Hassler	3	2			

Average number, 56.

Number of men attached to the Coast and Geodetic Survey vessels during the fiscal year ending June 30, 1888.

Name of vessel.	September 30, 1887.	December 31, 1887.	March 31, 1888.	June 30, 1888.
Steamer Arago	2	2	3	2
Steamer Bache	36	38	38	38
Steamer Blake	37	39	39	37
Steamer Barataria	1	2	1	....
Barge Beauty	1	1	1	1
Steamer Daisy	11	4	3	12
Schooner Drift	1	1	3	....
Schooner Eagre	23	14	6	23
Schooner Earnest	15	7	10	16
Steamer Endeavor	20	6	14	25
Steamer Gedney	27	25	30	27
Steamer Hassler	13	11	6	33
Steamer Hitchcock	2	2	2	2
Schooner Matchless	2	2	2	1
Steamer McArthur	29	27	28	29
Steamer Patterson	45	34	34	45
Schooner Palinurus	2	1	2	....
Schooner Quick	1	1	1	1
Schooner Ready	1	1	3	....
Schooner Scoresby	16	16	14	15
Schooner Spy	....	....	....	3
Schooner Yukon	1	1	1	1
Total	286	235	241	311

Average number of men, 268.

APPENDIX No. 6.—1888.

IN TWO PARTS.

PART I.—THE VALUE OF THE "ARCANO DEL MARE" WITH REFERENCE TO OUR KNOWLEDGE OF THE MAGNETIC DECLINATION IN THE EARLIER PART OF THE SEVENTEENTH CENTURY.

By CHARLES A. SCHOTT, Assistant.

The extreme paucity of reliable magnetic records in the two centuries preceding the year 1700 is well known, hence any work falling within this period and apparently overlooked (as we find no mention of it either in Hansteen's Magnetismus der Erde nor in Humboldt's Cosmos), would deserve careful examination respecting the value of its contents concerning terrestrial magnetism.

We became first acquainted with the work through Volume II of Justin Winsor's "Narrative and Critical History of America," Boston and New York, 1886, and introduced some information derived from it on pp. 310 and 380 of the Annual Report of the Coast and Geodetic Survey for 1886. Further attention was lately drawn to the work, and at the suggestion of Assistant George Davidson, the Superintendent applied to the librarian of Harvard College, Cambridge, to have the work examined for any magnetic data it might contain. Through the courtesy of Mr. Winsor, who allowed the work to be sent to Washington, we were enabled to make all desirable extracts, and to have some of the charts bearing on North American waters photographed for our historical collection.

The work consists of two large folios bearing the title "Dell 'Arcano Del Mare, Di D. Rvberto Dvdleo Dvca Di Nortvmbria, E Conte Di V Varvich; Libri Sei." It is dedicated to "Al Serenissimo Ferdinando Secondo, Gran Dvco Di Toscana," and was printed "In Firenze nella stamperia di F. Onofri, 1646;" Volume I, in two parts, contains the text, and volume II, bearing date 1647, is entirely made up of boldly engraved charts from the hands of A. F. Lucini. These charts comprise all regions then known to the navigator, but in our remarks we shall confine ourselves wholly to those charts which relate to North America or to waters adjacent thereto.

This elaborate nautical work, entitled the "Mystery of the Sea," treats of astronomy as applied to navigation, of nautical instruments, the construction of ships, the art of navigation, tactics and evolutions of men-of-war, etc., etc. But what is of special importance to us, among the methods of finding the longitude at sea the author brings forward (chapters VIII and X, tomo I), as others had done before him, one that depends on the observed changes of the magnetic declination, and to this particular circumstance may be ascribed the frequent references to declinations (variations of the compass) made in the text and placed on the charts.

Unfortunately there is no explanation respecting observer, date, or position, nor could we find any tabular statement or any direct reference to the values delineated on the charts, whether from *bona fide* observations or possibly interpolated values; great care is therefore necessary in estimating the real value of the information thus presented. Upon the whole the recorded declinations appear to be trustworthy, and if any interpolated values are given on the charts they are probably few in number and in some cases may admit of recognition.

The longitudes of the charts are counted eastward from the island of Pico,* one of the Azores; the modern determination of its initial meridian is 28° 28'. 2 or $1^h 53^m 52^s.8$ W. from Greenwich. (The latitude of Pico is 38° 25'.0.) East declinations are indicated on the charts by the term "variatio grecale" (*i. e.*, east of north), and west declination by "variatio maestrale" (*i. e.*, west of north); such expressions as "la bussola grecheggia" and "la bussola maestreggia" may be rendered "the compass (north end of needle) turns toward the east and towards the west," respectively.

The charts appear to be a great advance on those preceding them, being remarkably free from graphical conventionalism and distinguished by clearness and correctness as then understood, yet the work repeats two geographical blunders of its time, viz: the definite location of the island of Frieslandia to the southwest of Iceland and between it and Greenland, and secondly, the close approach of the coast of Asia towards the coast of California.†

Like the earlier so-called variation charts of Andrea Bianco (1436) and of Alonzo de Santa Cruz (1530), the Arcano del Mare only records the declination without any attempt to generalize the data, charts of iso-magnetic curves not being then generally known on account of their novelty. The first chart on the latter principle is due to Father Christopher Burrus, of Lisbon (died in 1632). In consequence of the absence of the date to the declinations, as given on the charts of the Arcano, no definite epoch can be assigned to any of these magnetic data, and if we reflect that it was the general belief in those times that the declination at any one place was *invariable*, it is certain that the collected data must be taken as spreading over a number of years prior to 1646; nor must we forget that the diffusion of knowledge was then quite slow.‡ The first writer who clearly asserted the existence of a change in the declination with time was Gellibrand (Discours mathematicall on the variation, etc., 1635). Thus it is highly probable that the greater part of the declinations given in the Arcano must be referred to some time in the second quarter of the 17th century. If we look for internal evidence of the dates, it would seem that, in general, the latest information is given, though in some cases the values may even refer to the preceding century, as for instance in the case of the declinations given on the coast of California, off Cape Mendocino and off Punta de los Reyes, which in all probability refer to time of Drake; perhaps nothing later was procurable for this then out of the way coast. The declinations given in the West Indies indicate data intermediate in time between 1600 and 1700, at any rate, later than the declinations upon which Hansteen based his isogonic lines for the year 1600; while the declinations given for the coast of Nova Scotia and the New England States appear to be other than those observed by Champlain (1604–1612) and Hudson (1609), and they are more consistent among themselves than those given by these navigators.

In view of the fact that the secular variation generally affects the declination at a moderate rate, we may, in the absence of any better information, and when some definite date is desirable, assume 1630 $\pm$ 15 years as probably not leading to any great error.

With reference to North America and adjacent regions, I have collected all the declinations given in the Arcano and placed them, as near as their exact location could be given, on the accom-

* The adoption of one of the islands of the Azores for the location of the initial meridian in counting longitudes is said to have come about through the circumstance that at the time of adoption the variation of the compass-needle was zero or nearly zero at those islands, but for positions to the eastward the variation was easterly and increasing with distance from them, and for positions to the westward the variation was westerly and increasing. The temporary selection of this initial meridian is thus connected with the great problem of determining longitude at sea by the aid of the direction of the horizontal magnetic needle.

† The former error is due to a voyage of the Fratelli Zeni (1388–1404), alleged to have been made to high northern latitudes, and of which an account was first printed in Venice in 1558, the existence of which in manuscript had long been known; Columbus also knew of this mythical island, which is now supposed to refer to one in the German Ocean. The other error is simply a remnant of the older belief, according to which the newly discovered part of Central America was no other than the extreme eastern part of Asia

‡ Since writing this article I became aware of the discovery, by Dr. John G. Kohl, of certain of Dudley's MS. maps at the Munich Library. He gives 1630 as the date for the maps of the "Arcano" (see Bibliographical Contributions No. 19, by Justin Winsor; issued by the library of Harvard College, Cambridge, 1886.) The charts necessarily cover a period of a number of years, though the bulk of them was probably completed in 1630, and it is said that an earlier edition of the Arcano of that date exists. Kohl mentions the year 1621 as the latest date on the MS. of the map showing the northwest coast of California (Sir Francis Drake's discovery in 1579), and Winsor remarks "that the map, Nova Belgica et Anglica Nova of Blaeu, Amsterdam, 1635, was largely followed by Dudley"—Dudley died in 1639.

So far as terrestrial magnetism is concerned, determining the exact date of each chart is of less moment, since the effect of the secular variation of the declination during a few years is but a small part of the probable uncertainty of the recorded observation itself; the latter may be estimated at about 2°.

June 11, 1888. S.

panying map (Illustration No. 19), where they are shown by ×'s. To judge better of their intrinsic value and to render the information more useful for the study of the secular variation, I have also delineated on the map the system of isogonic curves, which result directly from a simple graphical process. These curves exhibit but very moderate deviations between observation and representation, and they seem to confirm the curves constructed by Hansteen for the epoch 1600, and they clearly place themselves intermediate between this earlier epoch and that of Halley's Tabula Nautica, a century later. Among these lines there is one of special interest, namely, the agonic line, for the epoch of the Arcano, which swept over the North Atlantic, and is delineated on the accompanying map (Illustration No. 20) by means of the following data found in the Arcano. First, on the east coast of South America, south of the Orinoco, in latitude $+8^\circ$, there is little declination west; in latitude $+1^\circ$ the declination is $\frac{3}{4}^\circ$ west; in latitude -5° it is small, probably east; and in latitude $-8\frac{1}{2}^\circ$ the declination is 3° east; thus the line of no declination probably intersected the South American continent in latitude -5°, or in the vicinity of Cape San Roque. Next, in the bay of Panama, in latitude $7\frac{1}{2}^\circ$, off Point Chame, we have the declination $\frac{3}{4}^\circ$ west, and off Burrica, between Nicaragua and Veragua, the declination is marked "inappreciable," this is in about the same latitude; the agonic line must therefore have passed from Point Burrica through Costa Rica and across the lake of Nicaragua, since we find already 1° east declination in latitude $10\frac{3}{4}^\circ$, longitude 86°, or off Point Juan. Thirdly, we find the declination zero at the island of Pico, in the Azores, with easterly declination to the east and westerly to the west of these islands. Fourth, we have the statement that at the Cape Verde Islands the declination was inappreciable, but at the Canary Islands reached 2° east. The sweep made by the agonic curve, as shown on our illustration, is thus justified, and when compared with the Hansteen's delineation of it for the epoch 1600, goes to show that it had not reached its extreme position at the beginning of the century. At all places situated within the western or concave bend of this agonic line the declination was westerly, and, in general, the westerly declination increases with increasing distance from the line; on the other hand, on its convex or easterly side the declination is of the opposite sign. The data given in the "Arcano" thus strongly indorse the belief that westerly declination prevailed in the region of the Greater and Lesser Antilles for about a century and a half after their discovery, but in Halley's time this was no longer the case, as shown in the following comparative table for some principal places or their sites.

DECLINATIONS IN THE WEST INDIES AND CENTRAL AMERICA.

	According to Hansteen's isogonic chart for 1600.	According to the Arcano. Epoch, about 1630 ± 15.	According to Halley's isogonic chart for 1700.	Apparent change to the eastward.
At New Orleans	13° W.	5½° W.	2½° E.	8°
At Key West	12 W.	6 W.	5⅛ E.	11⅛
At Havana	11¾ W.	6 W.	6 E.	12
At Port Royal	8 W.	4 W.	7⅛ E.	11⅜
At Barbadoes	3 W.	1 W.	5⅛ E.	6⅛
At Vera Cruz	8 W.	2 W.	7½ E.	9
At Panama	3 W.	0¾ W.	10 E.	10¾

These numbers, if reliable, would imply a rate of change much greater than any noticed afterwards in this region, and would necessitate a corresponding change in the form of our analytical expression for the secular variation, as heretofore given for these localities, in order that the formulæ may apply to the early times here in review. However, Hansteen's chart for 1600 rests upon very scanty observations* and on wide interpolations, while the values taken from the Arcano appear systematic and may be assumed to rest on independent data; nor do the Halleyan values impress us with any feeling of accuracy; they certainly have the character of extreme values, and were probably influenced injuriously by observations made in Jamaica, where the needle may have been locally

*His sources were: Purchas's Pilgrims or Hacklnitus posthumus; Edward Wright, certain errors in navigation detected and corrected, and Athanasii Kircheri Magnes, sive opus de arte magneticâ.

deflected. The difficulty of recognizing the true law of change from conflicting testimony may be exemplified in the case of Port Royal, where, according to Robertson, the declination was 6½° East in 1660, and hence contradictory to the values given by Halley and in the Arcano. According to our researches the easterly declination at Port Royal reached its maximum about 1778 with 6° 2′ East. We are still reluctantly compelled, from want of sufficient data, to confine our analytical expression for the law of the secular variation for stations in this part of America to times after the middle of the 18th century.

Turning now our attention to the coast of New England we can there confront the information given in the Arcano with the somewhat earlier observations made by Champlain and Hudson. It should be remarked that the observations made by these navigators were difficult to reconcile. Champlain's observations between Nova Scotia and Cape Cod varied but little in amount (about 2°), but indicated high westerly declination, whereas Hudson's were extremely irregular, and as far as could be made out were of small westerly declination. Now, the Arcano gives values lying between these two extremes, and moreover confirms Hudson in making the declinations decrease when passing to the southwestward and thus disposes of the anomaly shown in Champlain's values, which indicated the opposite direction. Champlain's observations date between 1604 and 1612, with an average value for the Gulf of Maine of 18° W.; Hudson's refer to 1609, when on his third voyage, and his results range from 10° W. to zero, whereas the Arcano gives 12½° W., and apparently does not contain any value attributable to these navigators.

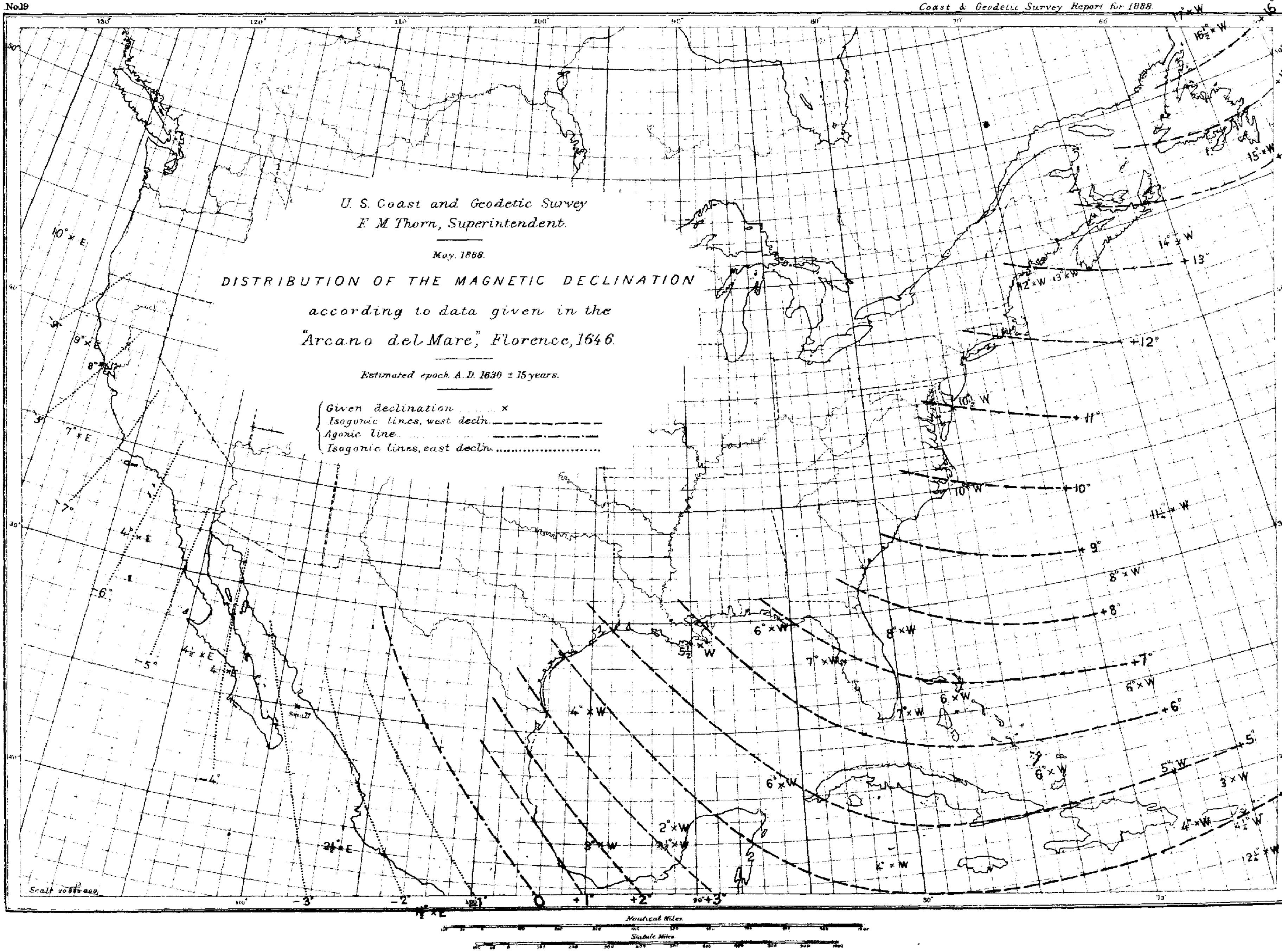
The declinations given in the Arcano, in the region of the Gulf of Maine, would seem to demand a correction of about + 2°, and to Champlain's results on the coast of Maine and Massachusetts I am inclined to assign corrections between — 1° and — 3°, and his large but consistent values may possibly find a ready explanation in the custom of European navigators of this age to set their compass-card over the needle with an index error equal to the average magnetic declination prevailing over the regions ordinarily traversed by them, and this was particularly the custom with navigators of the northwestern coast of Europe. Compasses so fixed by the maker may give rise, when unnoticed, to a constant error, as is supposed above. The compass used by Hudson behaved differently, and its defect is easily accounted for by supposing that the needle had then parted with the greater amount of its original charge of magnetism—in other words, it had lost too much of its directive force to have been of any account.

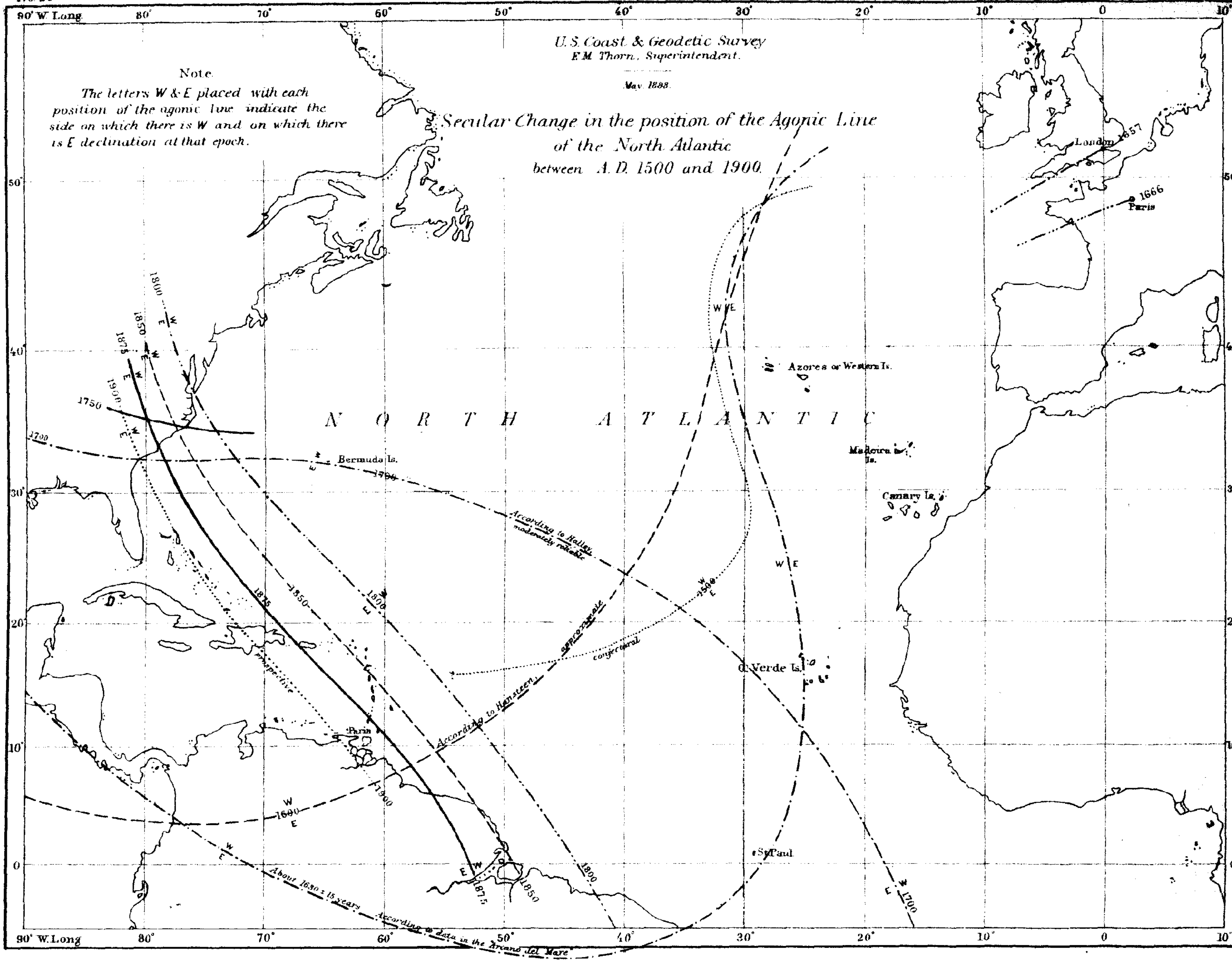
No critical examination was made of the magnetic information contained in the Arcano for other parts of the world, as these are not directly connected with the inquiry which brought the work under our notice; but if so extended, further light may be thrown on the sources whence its magnetic data were derived.

Upon the whole the scrutiny of the work left an impression favorable to its reliability, and if the omissions of observers' names and dates detract much from its value it nevertheless fills a gap in a period of which our information has heretofore been most scanty and unreliable.

CHARLES A. SCHOTT,
Assistant.

COMPUTING DIVISION, *May* 1, 1888.


U. S. Coast and Geodetic Survey
F. M. Thorn, Superintendent.
May, 1888.
DISTRIBUTION OF THE MAGNETIC DECLINATION
according to data given in the
"Arcano del Mare," Florence, 1646.
Estimated epoch A. D. 1630 ± 15 years.
Given declination ×
Isogonic lines, west decln.
Agonic line
Isogonic lines, east decln.
Nautical Miles
Statute Miles


U.S. Coast & Geodetic Survey
F.M. Thorn, Superintendent.
May 1888.
Secular Change in the position of the Agonic Line
of the North Atlantic
between A.D. 1500 and 1900.
Note.
The letters W & E placed with each position of the agonic line indicate the side on which there is W and on which there is E declination at that epoch.
N O R T H A T L A N T I C
Bermuda Is.
Azores or Western Is.
Madeira Is.
Canary Is.
C. Verde Is.
St. Paul
London
Paris
According to Halley, moderately reliable
According to Hansteen, approximate
conjectural
prospective
About 1630 ± 15 years
According to data in the "Arcano del Mare"
90° W. Long.
80°
70°
60°
50°
40°
30°
20°
10°
0
10°
1500
1600
1700
1750
1800
1850
1875
1900
1657
1666

PART II.—HISTORICAL REVIEW OF THE WORK OF THE COAST AND GEODETIC SURVEY IN CONNECTION WITH TERRESTRIAL MAGNETISM.

By CHARLES A. SCHOTT, Assistant.

Although one of the minor branches of the operations of the Survey, the study and application of the results of terrestrial magnetism from a practical point of view are of great importance, not only to the surveyor, but also to the mariner, to whom they are indeed indispensable.

This will be readily understood by simply referring to the extended use surveyors have made of the magnetic needle for the demarkation of land and the consequent frequent necessity of retracing old lines so laid out and recorded.

With reference to the needs of the navigator, the charts of the Survey require the impress of the compass; on these are recorded the variation of the needle, and the annual change is stated so as to render the sailing directions applicable for other years besides that of the issue of the chart. With reference to the adjustment of the compass on board ship and the construction of deviation tables to answer for different directions, inclinations, and positions of the ship, a knowledge of the magnetic dip and the intensity is demanded. The work of the Survey and the results secured may be advantageously shown by a short historical review.

In the early years of the Survey, under its first Superintendent, the magnetic declination (the scientific term equivalent to the mariner's "variation") was supplied on the charts as found by the ordinary nautical instrumental means then in vogue. In the transactions of the American Philosophical Society, Phila., 1825, he proposed to measure *relative* magnetic *intensity* by means of oscillations of a needle, no method for absolute measurement being then known. The magnetic work of the Survey, however, may be said to have commenced in its three-fold aspect—the declination, the dip, and the intensity—with his successor in office in 1843. Prof. Bache had previously made a magnetic survey of Pennsylvania, which, although a small beginning, was not followed until in quite recent years by the magnetic surveys of Missouri and New Jersey. He imported new instruments suitable for more refined measures of the declination than could be secured by the older instruments, and at the same time capable of exact determinations of the intensity in absolute measure; he also procured dip circles, and availing himself of the additional temporary aid of Dr. Locke, of Cincinnati, and of Prof. Renwick, of Columbia College, the work of observation was then fairly started, and has since been prosecuted uninterruptedly by various assistants of the Survey. In consequence of the dual or polar character of the magnetic force it resisted for a long time all attempts of measure expressible in the usual dynamical units, but in 1833 Gauss showed how this could be done; and after the invention, in 1836, of the portable magnetometer, his method for the absolute measure of magnetic intensity came into general use.

Those who are acquainted with magnetic observations, which also include those astronomical operations which involve geographical position and azimuth, know the delicacy and refinement of the operations when great accuracy is demanded, and it should also be remembered that in the early days of the development of practical methods there were none of those facilities we now possess in the number of trained observers, in the home manufacture of instruments, and in the many treatises for instruction now at hand. Apace with the field work the office work of computation and discussion has been prosecuted, and the results have been published from time to time in the annual reports.

At first the observations were confined to the vicinity of the sea coast, but it was soon found that the charts could not satisfactorily be supplied with the values for the variation of the compass unless the observations were extended sufficiently inland to give proper direction to the magnetic lines or isogonics as they are called, which curves exhibit for any place the angular difference between the astronomical and magnetic meridians for a certain epoch. Meanwhile, surveyors from all parts of the country have applied for information, not only for the present value of the declination, but, what was far more difficult to supply, for its value at some earlier period. To satisfy this inquiry, and to provide a better knowledge of the annual change of the declination needed for the charts, a more systematic general collection of all magnetic observations taken within the limits of the United States from the earliest to the present time was undertaken, and this register has been kept up since 1878, at which time the field of activity of the Survey was enlarged by the change of Coast into Coast and Geodetic Survey. This collection, arranged by States and Territories, now comprises several thousand observations, for declination, dip, and relative and total intensities, and together with the direct survey work, which in July last comprised 731 stations (many of them occupied several times at definite intervals), constitutes the material from which most of the deductions were derived, and which mark the advancement of our knowledge in this department of research due to the Survey.

The first permanent magnetic observatories in North America were established at Toronto by the British Government about 1840 (which observatory is still in operation under the auspices of the Canadian Government), and about the same time at Philadelphia, 1840–45, at Girard College. The latter was directed by Prof. Bache, who, after taking charge of the Coast Survey, took advantage of the newly invented application of photography to automatic registration, and procured one of the Brooke magnetographs, and caused it to be set up and to record continuously the variations of the declination and of the horizontal and vertical intensities at Key West, Fla., between 1860 and 1866. After the lapse of half a sun-spot cycle, which is the minimum duration for which it is profitable to keep up continuous observation at any one place, the instruments were transported to Madison, Wisconsin, where, between 1876 and 1880, a second series of observations was secured. When the support and co-operation of the survey were sought for the two international expeditions fitted out by the United States for polar research, the needed magnetic instruments, both absolute and differential, so far as the Survey could supply them, were furnished, and the observers were trained during the short time permitting.

The magnetic records of the second year (1882–83) at Point Barrow, Alaska, by the party in charge of Lieut. Ray, were made by the Brooke magnetometers, which had in the mean time been altered for direct or eye observations.

A superior self-recording magnetic apparatus, known as the Adie magnetograph, after the Kew pattern, and likewise working by means of photography, arrived here during the late war, but for want of funds was not set up until 1882; this superior instrument was located at Los Angeles, California, and continues to give excellent results. It is intended to terminate this series towards the beginning of the year 1890, and then to re-mount the instrument at San Antonio, in south-eastern Texas, and later on to move it to some place in Washington Territory, in order to cover as much as possible of the region, for which, heretofore, our knowledge of the laws of terrestrial magnetism has been most incomplete.

The first isogonic chart published by the Survey, entitled "Lines of Equal Magnetic Declination," will be found in the Annual Report for 1855; the last one, in three sheets, appeared in the Annual Report for 1882; a comparison between these charts will show in the most conspicuous manner the progress made in our knowledge in this direction during the interval. The index to scientific papers in the Annual Report for 1881, under the heading of Terrestrial Magnetism, enumerates no less than sixty-six titles up to the close of 1880; this will give some idea of the activity of the survey in this department. Several important investigations have appeared in the later Annual Reports; in the report for 1882 we have an appendix discussing the distribution of the magnetic declination in the United States for the year 1885, the results being based on observations at more than 2300 stations. In the report for 1885 we have an investigation of the magnetic dip and intensity, with their secular variations and their geographical distribution in the United States; this appendix, 145 quarto pages, involved great labor in its preparation; it is accompanied by three finely executed charts, besides the illustrations in the text; it discusses no less than 2000 dip observations and more than 1500 observations for intensity. The results for secular change of dip and intensity are new. In the report for 1886 (now published) Appendix 12 contains the sixth edition of an investigation, much sought after, namely, "The secular variation of the magnetic declination in the United States and at some foreign stations." From a small beginning in 1859 this paper has grown to be a complete depository of magnetic results available for the study of the secular change within our territory, and the author discusses most thoroughly the laws governing this mysterious movement, the cause of which is as yet entirely unknown, though in its nature it must be cosmical, since we cannot think of any adequate cause *within* the earth to produce, so far as we can judge, with remarkable regularity, the observed slow angular and supposed cyclic motion of the needle for centuries.

The deductions rest on 1071 observations made at 94 stations; the earliest observations on our western coast date from the 16th century (Sir Francis Drake), the earliest records on the eastern coast dating from the beginning of the next century (Hudson and Champlain). In this branch of research the Survey profited by the use of the valuable collection of declinations and dips, the earliest on record, made by Prof. E. Loomis (now of Yale College) who published them in Silliman's Journal in 1838 and 1840, and without which our results would not possess the extent and degree of reliability they now have. In this 6th edition, which spreads over 116 quarto pages, we have minute references to observations, together with their critical examination. The resulting secular change, illustrated by several diagrams, is expressed analytically and is also given in tabular form; * the laws which so far have appeared to govern this motion are stated and embrace the whole of the area of the United States (inclusive of Alaska), and are given sufficient geographical expansion to facilitate their connection with similar relations referring to Europe, South America, and Eastern Asia.

The magnetic records brought home by the Polar Expeditions in command of Lieutenants Ray and Greely were placed in the care of the Coast and Geodetic Survey; this material was subjected to computation and discussion and arranged for the press. The Point Barrow work, 1881–83, forms part VI of the official publication of Lieut. Ray's expedition (published in 1885), and the work done at Fort Conger (1881–83), under Lieut. Greely, will form Appendix No. 139 of Vol. II of the official publication now passing through the press.

The reduction, analysis, and discussion of the automatically registered material at the magnetic observatories still awaits adequate computing force to bring out the many laws and complex relations involved in the ceaseless changes of the magnetic force.

When the Survey was called upon to be represented in the Government Exhibit at the Centennial Exposition of the Ohio Valley and Central States at Cincinnati, Ohio, 1888, the writer prepared an article on terrestrial magnetism and provided four miniature diagrams, reduced from the larger maps published by the Survey, as suitable illustrations of the present distribution of the terrestrial magnetic force, both in direction and intensity, within our geographical boundaries. As a matter of general interest, these reduced maps are here reproduced, together with a brief explanation.

NOTE TO THE FOUR SMALL MAGNETIC MAPS ILLUSTRATING THE DISTRIBUTION OF THE EARTH'S MAGNETISM ABOUT THE PRESENT TIME WITHIN THE AREA OF THE UNITED STATES.

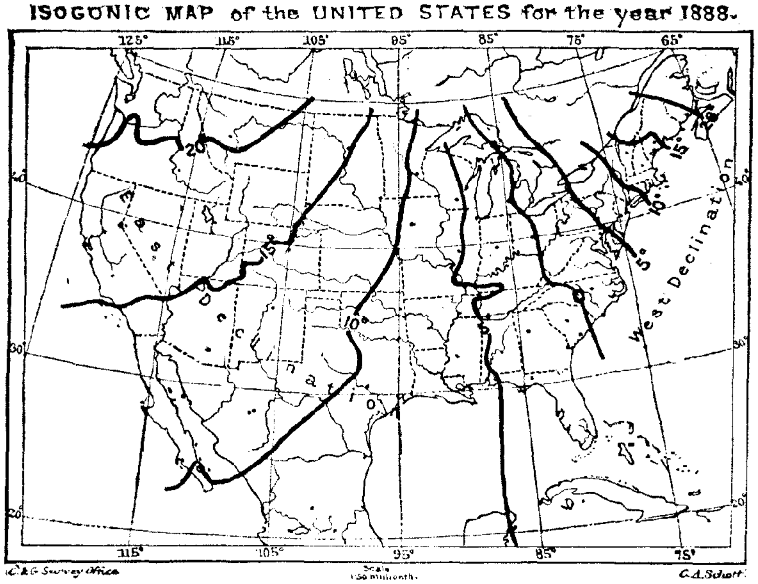
An isogonic curve is a line of magnetic declination which connects all places at which the angular deviation of a compass needle (or of a horizontal needle), from the true meridian, whether to the right or left of it equals the amount or degrees placed against it.

* For every station the declination is given for every tenth year from the time of the first observation up to 1850, after which time it is given for every fifth year to 1895, inclusive.

These curves are usually given for equidistant values and for whole degrees. In our illustration No. 1 they are drawn for each 5th degree.*

No. 1.

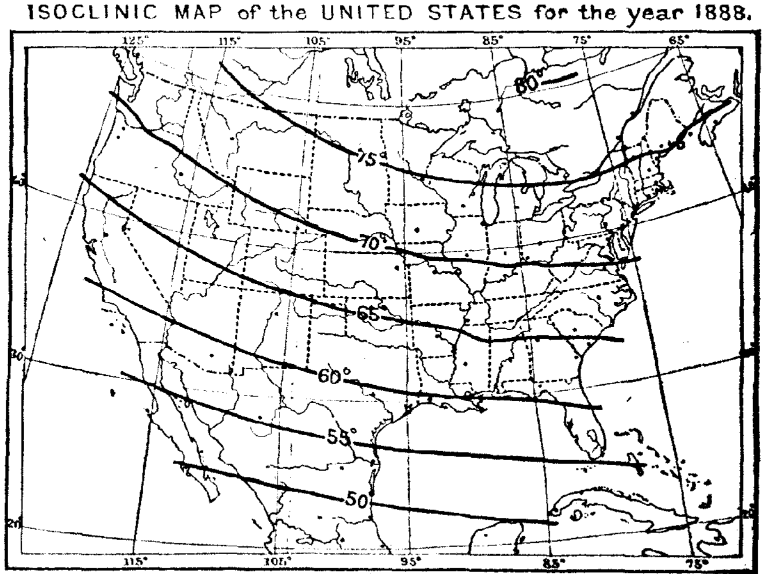
ISOGONIC MAP of the UNITED STATES for the year 1888.



An isoclinic curve is a line of given magnetic inclination, and unites all places where the dip of the north (pointing) end of a freely suspended needle equals the amount or degrees placed against it. The dip is measured from the horizontal plane and may be downward, as for our illustration No. 2, or upward, as in the southern hemisphere. Isoclinic curves are generally drawn for equidistant values, in our illustration for each 5th degree.

No. 2.

ISOCLINIC MAP of the UNITED STATES for the year 1888.



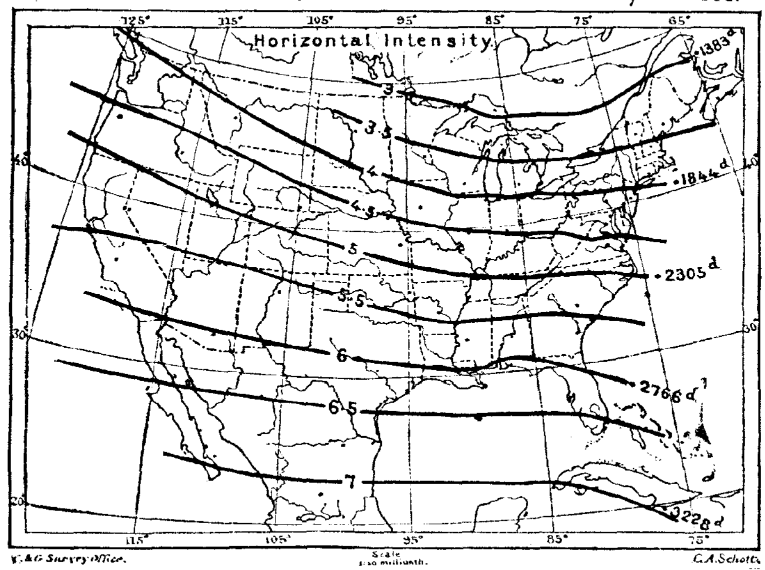
An isodynamic curve is a line of given intensity of the *horizontal* component of the earth's magnetic force, and is drawn through all places where the horizontal intensity is of the amount placed against it. The intensity is expressed either in units of the foot, grain, and second (the old English units), or in units of the centimetre, the gramme, and the second (the new C. G. S. units or dynes).

* The four maps were constructed for the epoch 1885 and No. 1 answers more strictly to that year; for the other maps the change during three years is not noticeable.

In our illustration No. 3 the intensities are given in both units, and the curves are at equal intervals of half a unit of the English scale, or of 0.023 dynes of the C. G. S. system. The numbers in the middle of the map refer to the old units.

No. 3.

ISODYNAMIC MAP of the UNITED STATES for the year 1888.



An isodynamic curve may also be a line of a given intensity of the *total* magnetic force, and is drawn through all places at which this intensity is of the given amount. The unit of force is the same as explained above, and the intervals of the curves on our map are for whole and half English units, or for 0.0461 and 0.023 dynes.

The numbers in the middle of the map refer to the old units. The epoch for the distribution of intensities is likewise the beginning of the year 1885. In all cases, however, the annual change is so small that the maps answer equally well for the present time, and they were consequently marked for the year 1888.

No. 4.

ISODYNAMIC MAP of the UNITED STATES for the year 1888.

The annual expenditure on account of terrestrial magnetism is quite small, being only about $\frac{1}{200}$th part of the whole appropriation for the Survey, but it is to be hoped that this useful and interesting branch of terrestrial physics may hereafter receive a more liberal support.

CHARLES A. SCHOTT,
Assistant, Coast and Geodetic Survey.

COMPUTING DIVISION, *June* 7, 1888.

APPENDIX No. 7.—1888.

THE SECULAR VARIATION OF THE MAGNETIC DECLINATION IN THE UNITED STATES AND AT SOME FOREIGN STATIONS.

By CHARLES A. SCHOTT.
Assistant, Coast and Geodetic Survey.

[Seventh edition, June, 1889.]*

Introduction.—The practical nature of the inquiry, and the necessity of looking to the publications of the Coast and Geodetic Survey to supply the latest information on the subject of the changes, secular and otherwise, of the direction of the magnetic needle, has caused an ever-increasing demand for the results of these investigations now conducted by the Survey for thirty years, and this in turn has acted as a stimulus to advance our knowledge of the secular changes of the magnetic force, both for direction and intensity, and to keep the results up to date. It thus becomes necessary from time to time to submit to analysis any additional observations, to re-discuss the older series, and publish the results at intervals of a few years, as well as to direct new observations to be made at those places where they may contribute most effectively towards the elucidation of the laws of change.

Appendix No. 6, Coast and Geodetic Survey Report for 1885, contains an exhaustive article on the secular change of the magnetic dip and the magnetic intensity, as observed in the United States from the earliest to the present time. It is accompanied by three maps, showing the actual distribution of these magnetic elements for the epoch 1885.0. This, together with the present communication, completes the inquiry in this branch of knowledge as far as this could be done at the present time.

During the two years which have elapsed since the last issue of this paper the available material for the discussion of the secular variation of the declination has greatly increased, bringing up the number of stations contained in this edition to 109 and the number of declinations to 1245, for each of which full reference is given, as well as a comparison of the observed and computed values. The average number of observations for a station is 11. It is satisfactory to remark that

*This article originally appeared in Coast Survey Report for 1855, Appendix No. 48, and was continued in Reports of 1856, 1858, and 1859, Appendix No. 24, pp. 296–305. In the second edition, in Coast Survey Report for 1874, Appendix No. 8, pp. 72–108, the investigation appears greatly extended; the substitution of a sine for a cosine function was made and the epoch was changed from 1830 to 1850; also some use was made of Cauchy's method of interpolation for the establishment of some second periodic terms. The third edition, issued in June, 1879, appeared in pamphlet form, and is not contained in any annual report of the Coast and Geodetic Survey. The geographical range of the investigation was much enlarged, and the paper was illustrated by two plates. The next or fourth edition was brought out in June, 1881, and forms Appendix No. 9, Coast and Geodetic Survey Report for 1879; it was illustrated with three plates. In the fifth edition, of November, 1882, Appendix No. 12, Report for 1882, there were discussed 837 declinations, observed at 82 stations, situated in the United States and a few in Europe, South America, Asia and Polynesia, the latter for the purpose of extending our knowledge of magnetic changes beyond our immediate sea coast. The sixth edition forms Appendix No. 12, Annual Report for 1886; it is distinguished by a more systematic arrangement of its contents and by a more liberal introduction of observations made at sea near our coasts, besides, the number of stations to which the record and discussion extends, is increased to 94 with an available material of 1071 observed declinations.

the introduction of the new observations tended greatly to improve the numerical values of the analytical expressions, and to give greater accuracy to the results deduced, as well as to produce greater uniformity in such phases of the secular variation as the amplitude of the motion and the epochs of maxima and minima or times of magnetic elongation, so far as these depend on the geographical position of the stations.

In the collection of observed declinations, as heretofore given, I had sparingly made use of observations taken on board ship, introducing such observations only from necessity, *i. e.*, in the absence of observations on land; but in the last and present discussion apparently trustworthy observations made at sea have been more freely introduced, and in the case of the great number of observations by Spanish navigators towards the close of the past century, along our Pacific coast, their united testimony has greatly benefited our range of knowledge by giving greater security and unity to results which before appeared doubtful or scattered. The collection of this material is contained in Appendix No. 7, Coast and Geodetic Survey Report for 1885, and was communicated by Assistant G. Davidson. Its value was then conjectural, but the discussion of it proved to be highly creditable to the reputation of the navigators of that period. I find the average probable uncertainty* of a declination (variation of compass) observed on board the wooden hulls of those times not to exceed $\pm$ 1°, the same as I had assigned to the observations taken by Vancouver, an amount which probably represents the best practice of that epoch.

In our own times, for vessels composed of iron and steel, and otherwise largely supplied with such metal, when swung on (say) 8 or 32 equidistant points of the compass, the observed declination will still be subject to a probable uncertainty of about $\pm$ 0°.5 to $\pm$ 0°.3

The immediate object of the discussion of the secular change of the declination is to furnish the means of referring observed declinations from one epoch to another, as, for instance, when surveyors are required to re-discover and re-trace old lines originally run by compass, but which had become obliterated in the course of time, or when the variation is demanded for the compasses placed on the sailing coast and harbor-charts of the Survey. The principal demand for the results of this article comes, however, from surveyors and from members of the legal profession, which demand frequently arises from litigation in cases of disputed land boundaries. Since the source where such information could be had became better known, the number of applications to the

To facilitate reference to stations and results, the contents of the paper are arranged in three parts—an eastern, middle, and western division—in which the places follow in geographical order; and the final tables of results give the declinations, after the year 1850, for every fifth year, instead of for every tenth as in the older editions. The tables are extended to include the year 1900, the predictions for that epoch, however, must necessarily remain *rough approximations*. To render this investigation more useful to practical men, I have thought it desirable to preface it with a brief account of the *principal* motions, systematic as well as apparently irregular, to which the direction of the magnetic needle has been found subject, in order to clearly separate and distinguish these changes from the secular variation, which last is here made the special object of treatment.

The magnetic declination.—The magnetic declination (or variation of the compass, as it was formerly called by surveyors and still is by navigators), at any place, is the angle contained between two vertical planes, one being the astronomical or true meridian, and the other the plane in which the horizontal axis of a freely suspended magnet lies at the time. The former plane is fixed and the latter variable, since it is found that the needle when delicately suspended is generally in a state of slow or tremulous motion. The magnetic declination varies with respect to space and time; it is, therefore, necessary to give with the statement of its measure the exact time (year, day, and hour) when an observation was made, as well as the geographical position of the place (the latitude and longitude, it suffices to give these co-ordinates to the nearest minute of arc). The declination is called "west" when the *north* end of the magnet points to the west of true north; algebraically this fact is here indicated by a + sign, and if "east" by a − sign. It is a matter of observation that the magnet, when light, and delicately suspended (by a single fibre of raw silk) is seldom or never at rest, but is always shifting its direction, or is in a state of oscillation or of tremor, and occasionally

* Used in the sense of probable error in the method of least squares.

subject to sudden violent and irregular changes. These angular motions have been classified as regular (periodic) and irregular variations, and of these we propose to notice briefly the principal ones, as also their magnitudes as they may be met with within the limits of the United States.

The *solar-diurnal* variation consists in a systematic angular movement of the direction of the magnet, having for its period the solar day. Its phases depend on local time, and its character is the same for the greater part of the northern hemisphere; viz, about the time of sunrise the *north* end of the needle is generally found approaching to or near its most *easterly* extreme or elongation from the magnetic meridian. This phase happens, for instance, at Philadelphia, on the yearly average, about 8^h a. m.; at Key West, Fla., about $8\frac{1}{4}^h$ a. m.; and the same at Madison, Wis. It is subject to an annual variation, being about three-quarters of an hour later in the months when the sun is south of the equator, and about one-half of an hour earlier in the summer months than its yearly average time of occurrence. The north end of the needle then begins its principal daily motion, and reaches the opposite extreme position, or its western elongation, about half past 1 o'clock p. m. It is reached a few minutes earlier in summer and a few minutes later in winter, and hardly varies half an hour for different localities. After this epoch the needle takes up an easterly movement and gradually returns nearly to the direction from which it set out in the morning. Frequently an interruption, or small reversed motion, is exhibited during the night. At Philadelphia the average daily direction is reached in summer about $10\frac{1}{4}^h$ a. m. and in winter about $10\frac{3}{4}^h$ a. m., and generally within half an hour of these times at other places. The magnetic meridian is crossed a second time, generally between 7 and 9 p. m. The angular range between the morning and afternoon elongations, or the diurnal range, is about 8′ on the average at Philadelphia and about $5\frac{1}{2}'$ at Key West; in higher magnetic latitudes it is more, in lower less. This range is subject to an annual inequality, being much more conspicuous in summer than in winter (12′ at Philadelphia in August and 5′ in November). At Sitka, Alaska, the diurnal variation from observations between 1848 and 1862 showed an average range of $10\frac{3}{4}'$ with the easterly extreme at 8 o'clock a. m., and the westerly extreme about $3\frac{1}{2}$ p. m. At Point Barrow, on the Arctic Ocean, in latitude 71° 18′, the daily range is nearly 40′ with the easterly extreme about 8 o'clock a. m., and a delayed westerly extreme about 5 p. m.—as observed by Lieut. P. H. Ray. At Lady Franklin Bay, Grinnell Land, in latitude 81° 44′, the daily range, on the yearly average, rises to 1° 6′ with an easterly extreme as early as $1\frac{1}{2}$ a. m., and a westerly extreme as early as 1 p. m.—as observed by Lieut. A. W. Greely. It is further subject to a periodic inequality related to the eleven-year cycle of the sun-spots. The diurnal motion is least in years of minimum sun-spots (as in 1856, 1867, 1878 and 1889, for instance) and greatest in years of maximum sun-spots (as in 1860, 1870 and 1883), the factors being 0.7 and 1.3, about, of the average amount of these years respectively. This daily variation appears at times intensified, at other times enfeebled, and during the winter months there are occasionally days on which it can not be recognized. Observations must be corrected for time of day in order to reduce the result to the average direction of the twenty-four hours; a table given for this purpose is found in Coast and Geodetic Survey Report for 1881, Appendix No. 8, Art. 6.

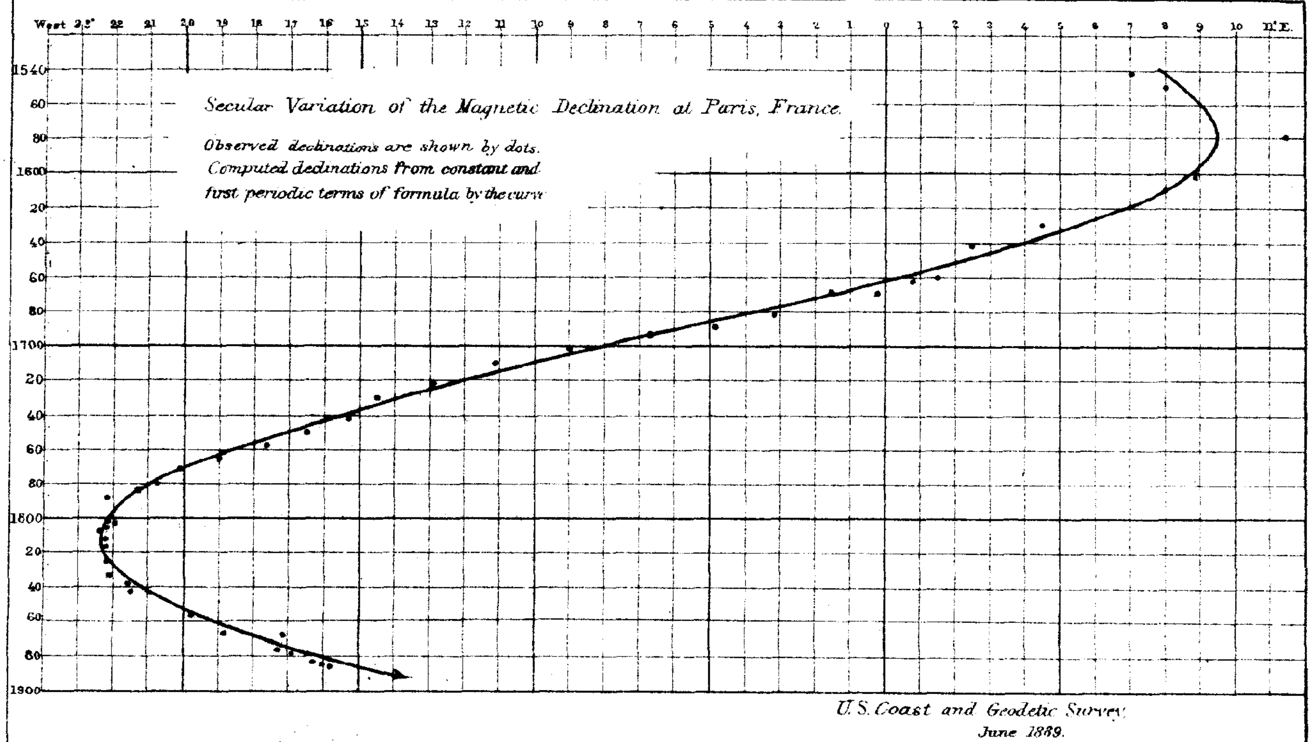
The *annual variation* of the declination is so small that a mere mention of its existence suffices; its amplitude is at most $1\frac{1}{2}$ minutes of arc.

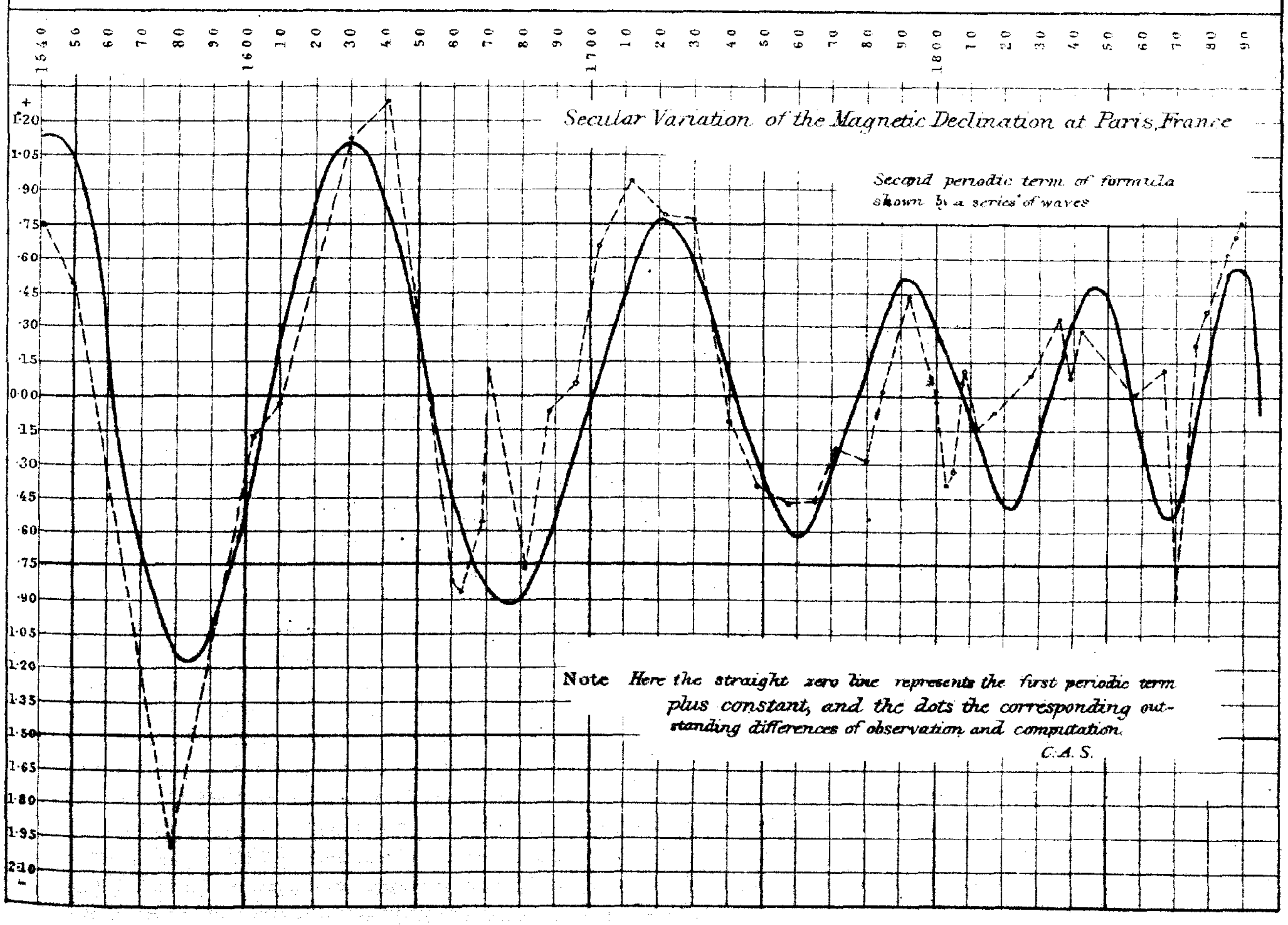
The *variation* depending on the *solar rotation* has a period of about twenty-six days; its amplitude is likewise small in our latitude.

The lunar inequalities: These we also pass over on account of their small amplitude. The principal inequality of the lunar diurnal variation exhibits the peculiarity of two maxima and minima on each lunar day, thus partaking of the character of the tides. The range of this inequality at Philadelphia is about 27″, and at Toronto, Canada, about 38″. Other lunar inequalities are of yet smaller order.

The secular variation of the magnetic declination, our subject proper, is most probably also of a periodic character, but since it requires centuries for its full development, and since, as yet, no one cycle has actually been completed within the range of observation, we are obliged, in the absence of any reliable theory, to follow up the phenomena, tentatively, by continuous observations. The secular motion may be compared with a wave motion or with an oscillation of a pendulum which comes to rest momentarily at its extreme positions or elongations and moves fastest midway between these extremes. Smaller variations within this period have also been detected, but the general angular movement (say of the north end) of the magnet may be described as follows: About the times of maximum deflection the magnet appears almost stationary or only slowly oscillating about the same average direction for several years (as observed by ordinary or rough instruments); soon, however, the effect of the secular change becomes perceptible, increasing gradually, year by year; this progressive angular motion soon reaches an annual maximum value, after which, still moving in the same direction, it slowly diminishes in speed and finally becomes again stationary, now at the opposite extreme digression, after which *possibly* it will return again to its first position. Within the area of the United States and south of latitude 49° a complete oscillation of this kind may require between two and a half and three and a half centuries, during which time the magnet would swing twice, i. e., once forward and once backward, through an arc of several degrees, generally keeping within the limits of 4° and 8° of total range for our geographical boundaries; in other localities the period and range are very much greater. The remarkable regularity of the motion is well shown on the accompanying diagram (illustration No. 21) for Paris France (selected on that account), for which place we probably possess the longest series of observations; the period is about four and two-third centuries, and the range nearly 33°. To illustrate further the effect of the secular change, we may take the case of New York City. In this locality the needle was observed to be in nearly a stationary condition about 1682, its north end pointing then fully 9° to the west of north; it then moved easterly and reached its easternmost digression about 1784, showing at that time only $4\frac{1}{3}$° west declination. Ever since this epoch the motion has been westerly, its present value being nearly $8\frac{1}{2}$° W.; the greatest annual change (nearly 5′) was apparently passed about the middle of the century. The times of these stationary epochs are different at different localities; the last epoch of eastern elongation was noted earliest in Maine towards the close of the past century, later the Mississippi Valley, and it has now reached the coast of California and of Washington Territory. At present over nearly the whole of the United States the effect of the secular change is to *increase* west declination, or (what is the same) to *decrease* east declination; but on parts of the Pacific coast and for some short distance in the interior the effect is still opposite, viz, an *increase* of east declination. Alaska, however, is to be excepted; there easterly declination is now slowly decreasing. There are, consequently at present two regions or belts of no change, one in the east, just entering the State of Maine, the other, on the west coast of California, Oregon, and Washington Territory, just passing out to sea. They will be referred to in detail further on. It is this regular motion, known as the secular variation, which renders it necessary to reconstruct isogonic charts from time to time and to correct the compasses and magnetic bearings on our charts. Although this secular variation is perfectly systematic, it does not generally appear so; the observations are more or less irregular when made at different places in the same general locality, either on account of small observing errors or in consequence of local deflections, or for the reason that the ordinary daily variation and other inequalities have not been fully eliminated from the results. Among the latter irregularities must be classed the—

Magnetic disturbances or storms.—These may occur at any time, and are, when taken individually, beyond the power of prediction; but attacked by the statistical method, *i. e.*, when classified and when averages are taken of many thousands, they are found to be subject to various laws. Their presence is generally indicated by sudden deflections, and by rapid and great fluctuations of the direction of the needle as compared with its normal position, which otherwise might have been expected at that time of day and month. They often take place simultaneously over distant regions of the globe, and in duration may be confined to a few hours, or they may last a day or even for several days. They are frequently accompanied by auroral lights and by strong electric earth-currents. When analyzed in large numbers they exhibit a solar-diurnal variation, the westerly and easterly disturbances, however, following different laws. They also have an annual variation and seem to depend largely on the eleven-year cycle of the sun-spots. Irrespective of direction of the disturbing forces the most disturbed hours of the day are generally those between 7^h and 10^h a. m., and the least disturbed those between 2^h and 6^h p. m. Westerly disturbances occur most frequently about 8^h a. m., and least about 8^h p. m.; they exhibit a *single* daily progression. Easterly disturbances reach a maximum about 8^h p. m. and a minimum about 2^h p. m.; they exhibit a *double* daily progression. Westerly and easterly disturbances appear to agree in their annual variation, in their times of maxima, *i. e.*, in August, September, and October, and in their times of minima,


Secular Variation of the Magnetic Declination at Paris, France.
Observed declinations are shown by dots.
Computed declinations from constant and first periodic terms of formula by the curve
West 23° 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 10 11° E.
1540 60 80 1600 20 40 60 80 1700 20 40 60 80 1800 20 40 60 80 1900
U. S. Coast and Geodetic Survey
June 1889.


Secular Variation of the Magnetic Declination at Paris, France
Second periodic term of formula shown by a series of waves
1540 50 60 70 80 90 1600 10 20 30 40 50 60 70 80 90 1700 10 20 30 40 50 60 70 80 90 1800 10 20 30 40 50 60 70 80 90
+ 1·20 1·05 ·90 ·75 ·60 ·45 ·30 ·15 0·00 ·15 ·30 ·45 ·60 ·75 ·90 1·05 1·20 1·35 1·50 1·65 1·80 1·95 2·10 −
Note Here the straight zero line represents the first periodic term plus constant, and the dots the corresponding outstanding differences of observation and computation.
C. A. S.

i. e., in January and June. The disturbances are most frequent and considerable in the years of maximum sun-spot activity and the reverse in years of minimum sun-spots. The following table of the observed disturbances, in a bi-hourly series at Philadelphia in the years 1840 to 1845, will give an idea of their relative frequency and magnitude:

Deviations from normal direction.	Number of disturbances.
3′.6 to 10′.8	2189
10′.8 to 18′.1	147
18′.1 to 25′.3	18
25′.3 to 32′.6	3
Beyond	0

At Key West, Fla., the maximum deflection noticed between 1860 and 1866 was 21′.4. At Madison, Wis., where the horizontal magnetic intensity is considerably less, very much larger deflections have been noticed. Thus, on October 12, 1877, one of 48′, and May 28, 1877, one of 1° 24′. In high magnetic latitudes where the horizontal component of the magnetic force is feeble, the disturbances attain great intensity, thus at Lady Franklin Bay, Grinnell Land, Lieut. Greely noted an extreme *range of declination* of not less than 20° 28′, this occurring during the great November storm of 1882.

We now proceed to the special consideration of the secular variation of the magnetic declination, beginning with an account of its first recognition.

Historical note.—The following brief historical remarks on the magnetic declination and its secular variation have been prepared from extracts from Humboldt's Cosmos (Otte's translation, London, 1849–1858), Vol's II and V; from the Encyclopædia Britannica, 9th edition, Art. Compass, Vol. VI (Boston, 1877), and from E. Walker's treatise "Terrestrial and Cosmical Magnetism," Cambridge, (England), 1866, in which works fuller references will be found. The Encyclopædia of Experimental Philosophy, London, 1848, Art. Magnetism, as well as Gehler's Physikalisches Wörterbuch, Leipzig, 1825, Art. Compass, were also consulted.

The first notice of the magnetic needle as applied to navigation we meet with among western (European) nations does not date further back than the eleventh or twelfth century of our era, but in China the directive property of the magnetic needle was made use of on land as early as the twelfth century B. C., and, according to tradition, even at a much earlier time (2634 B. C.). In the third and fourth centuries of our era Chinese vessels were guided by the magnetic needle, and through them a knowledge of the polarity of the needle was conveyed to India and thence westward. In the ninth century Chinese merchants traded in ships to the Persian Gulf and the Red Sea. Probably through the influence of Arabian navigators, or through the agency of the Crusaders, the use of the mariner's compass was introduced into Eastern Europe. Among the first European writers of the middle ages who refer to the loadstone or to the compass is the Icelandic historian, Are Frode, who lived about the end of the eleventh century. He states that the directive property of the loadstone was then known to seamen in northern countries. Next are mentioned, Alexander Neckam, in two treatises, "De Utensilibus" and "De Naturis Rerum," of the twelfth century; Guyot of Provins, in 1190, and Jaques de Vitry, between 1204 and 1215. Raymond Lully, in 1272 and 1286, remarks that the seamen of his time employed the magnetic needle, and from Torfæus we learn that the compass was in use among the Norwegians about the middle of the thirteenth century. Among then-western nations the construction of the instrument underwent great improvements, particularly by the hands of Flavio Gioja, of Amalphi, Italy, in 1302.

The declination.—From a Chinese work, written between 1111 and 1117 A. D., we learn that the needle was then suspended by a thread and that the mode of measuring the amount of the declination, it being then west (or, as there expressed, east of south), had long been understood. It can hardly be supposed that the fact of the needle, in general, *not* pointing exactly to the true north and south could have been overlooked in the twelfth century, on the coasts of the Mediterranean, in places where the declination reached 6° to 10°. A passage interpolated in a Paris MS., a copy of "Epistola Petri Peregrini," etc., of 1269, states the declination to have been determined by him in Italy at 5° E. Columbus probably was the first who records the change in the sign of declination with change of geographical position. On starting from the west coast of Spain he had east declination. In September, 1492, in the Atlantic, in latitude 28° longitude 28° (about) he observed 11° W. He has thus the merit of being the first to discover a part of an agonic line, or line of no declination. The first scientific work in Europe in which the declination is treated at any length and deduced from actual observations is that by Boroughs, published in 1581, entitled "A discourse on the Variation of the Cumpas or Magneticall Needle," and is dedicated to the "travaillers and mariners of England." In 1599, Prince Maurice, of Nassau, the lord high admiral of the Low Countries, recommended seamen to keep a register of the declination in every part of the world they might visit.

Isogonic charts.—It is supposed that on the chart of Andrea Bianco, drawn up in the year 1436, certain declinations only were marked, but Alonso de Santa Cruz, in 1530, constructed the first general declination chart, though based upon very imperfect material. Upon the chart by Father Christopher Burrus (who died in 1632), published at Lisbon, the magnetic lines are called "tractus chalyboeliticos." About 170 years after Alonso de Santa Cruz, Edmund Halley published his celebrated isogonic chart for the year 1700, based entirely upon observations. [Tabula Nautica, Variationum Magneticarum Index, juxta observationes anno 1700.] His voyages of the years 1698, 1699, and 1702 were undertaken at the expense of the British Government. This chart comprises the areas of the North and South Atlantic, the Indian, and the extreme western part of the Pacific Ocean. Isogonic charts became quite numerous after Halley's time. Those by Hansteen (Magnetismus der Erde, 1819) deserve special mention; his earliest one is for the year 1600. In 1838 Gauss published his "General theory of Terrestrial Magnetism" (in Resultate, etc., des Magnetischen Vereins, Göttingen) and the resulting isomagnetic curves were afterwards charted. A translation of the theory and copies of the charts are given in Taylor's Scientific Memoirs, Vol. II, London, 1841. In the work of A. Erman and H. Petersen, "The Foundation of the Gaussian theory and the phenomena of Terrestrial Magnetism in the year 1829," Berlin, 1874, the general distribution of magnetism over the globe is shown on six charts for the epoch 1829. For the most complete magnetic charts depending directly on observations, the reader is referred to General Sir Edward Sabine's Contributions to Terrestrial Magnetism, Nos. XI, XIII, XIV and XV, Phil. Trans. Roy. Soc., of the years 1868, 1872, 1875 and 1877, respectively. These charts refer to the period 1840 to 1845. Charts on Mercator's projection of "Curves of Equal Magnetic Variation" were published by the English admiralty for the epochs 1858, 1871 and 1880, and by the Deutschen Seewarte for 1880.* The latest isogonic charts for the United States of America, reduced to the epoch 1885.0, will be found in the Coast and Geodetic Survey Report for 1882, Appendix No. 13, in three sheets, Nos. 38, 39, 40, with a second edition of the first two numbers in one sheet, issued in February, 1889.

The secular variation of the declination.—The discovery of the gradual change of the declination, which for any one place had previously been supposed by philosophers to be constant, is due to Gellibrand, of Gresham College, England. In 1635 he published his work, entitled "A discourse mathematicall on the Variation of the Magneticall Needle, together with its admirable diminution lately discovered." He based his conclusions upon the recorded observations of Boroughs (1580), of Gunter (1622), and his own observations (1633-'34), showing that in the vicinity of London the direction of the needle had changed in the interval fully 7° to the westward. From this time the fact of the secular variation was completely established, and it remained to later times to determine its extent and develop the law governing this change, and to endeavor to find its cause. That the velocity was not uniform was soon perceived, and the apparently periodic character of the variation was prominently forced upon the attention of observers when the needle reached a stationary condition, as, for instance, in the eastern part of the United States towards the end of the eighteenth century, and then recommenced its motion in a direction *opposite* to that it had before. Similarly at Paris, France, the secular change was westward between the stationary epochs of 1580 (about) and 1812 (about), since which time the needle has commenced retracing its course eastwardly. Nearly midway between such stationary epochs the annual change is observed to be a maximum. See illustration No. 21, upper diagram.

* See also "Berghaus' Physicalischer Atlas," chart No. 39, which is for the epoch 1885.

ANALYTICAL EXPRESSION OF THE SECULAR VARIATION OF THE MAGNETIC DECLINATION.

The secular variation can be represented with considerable accuracy by means of a circular or harmonic function, as might be expected from the almost unlimited adaptation of such functions to all forms of periodically recurring phenomena, provided a sufficient number of terms are introduced. The formula employed for our purpose may be written—

$$D = \delta + r \sin(\alpha m + c) + r_{,} \sin(\alpha_{,} m + c_{,}) + r_{,,} \sin(\alpha_{,,} m + c_{,,}) + \dots\dots$$

Where D = magnetic declination at any time t, positive when west, negative when east.

m = number of years and fractions of a year from an epoch t_0 for which 1850 has been adopted; hence $m = t - 1850.00$

$\alpha\ \alpha_{,}\ \alpha_{,,}\ \dots$ are factors depending on the adopted periods $P\ P_{,}\ P_{,,}\ \dots$ of the several terms; so that $\alpha = \frac{360^\circ}{P}$ $\alpha_{,} = \frac{360^\circ}{P_{,}}$ $\alpha_{,,} = \frac{360^\circ}{P_{,,}}$, etc. Or in general $\alpha = \frac{2\pi}{P}$

Thus to $\alpha = 0.9$, 1.0, 1.2, 1.5 there correspond periods of 400, 360, 300, and 240 years respectively.

$r\ r_{,}\ r_{,,}\ \dots\dots$ are parameters or semi-ranges,

$c\ c_{,}\ c_{,,}\ \dots\dots$ epochal constants of the several periodic terms, and

δ = a constant, representing the average or normal declination about which the periodic fluctuations take place.

The quantities δ, $r\ r_{,}\ r_{,,}\ \dots\ \alpha\ \alpha_{,}\ \alpha_{,,}\ \dots$ and $c\ c_{,}\ c_{,,}\ \dots$ for any one locality must be determined from the observations made there at various times, and their most probable values are to be deduced by application of the method of least squares.

We begin by assuming a suitable value* for the length of the principal period, and the first periodic term of the formula is treated as follows:

Put $\delta = \delta_{,} + x$ where $\delta_{,}$ = an assumed approximate value of δ and x a correction to it; also put

$$r \cos c = y \quad \text{and} \quad r \sin c = z,$$

then the conditional equations will take the form:

$$0 = \delta_{,} - D + x + \sin \alpha m \,.\, y + \cos \alpha m \,.\, z$$

from which the numerical values of $x\ y\ z$ are to be deduced in the usual way by means of normal equations. To determine the value of α (and similarly of $\alpha_{,}\ \alpha_{,,}\ \dots$) the computation is repeated three times (or more if necessary) using the slightly changed values $\alpha + \Delta\alpha$ and $\alpha - \Delta\alpha$, from which that particular value of α is found and finally retained which renders the sum of the squares of the differences of observed and computed declinations a minimum. In some cases where certain observations were evidently less trustworthy than others, and which nevertheless could not be dispensed with owing to the small number of observations or on account of their special value with reference to time, *special* weights were assigned; generally each observation received the weight unity, a few imperfect observations the weight one-half, and to some particularly valuable observations double weight was assigned. In these cases the conditional equations were multiplied by the square root of their respective weight. The material on hand was thus carefully scrutinized respecting its relative and absolute value, and of observations evidently grossly in error no notice whatever was taken. In finally selecting what seemed to be the best expression for the secular change at a station, I have also frequently been guided by the accord of the various constants entering into the equation when compared with corresponding values in the equations for surrounding stations. When applying Cauchy's method of interpolation the form

$$D = \delta + r \cos c \,.\, \sin m\alpha + r \sin c \,.\, \cos m\alpha$$

was found more convenient in use. This method was employed for establishing such second or third periodic terms as appeared demanded by the observations, but only a few such terms could be determined as they generally failed in consequence of the insufficiency in number of data or for want of sufficient accuracy in the observations.

The annual change v of the magnetic declination due to the secular motion, positive when increasing west declination (or decreasing east) and negative when in the opposite direction; also

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* It may be found graphically in the first instance.

the epoch of minimum west declination (or of maximum east); also the amount of the declination at this epoch and the apparent probable error of an observation—are found as follows:

Differentiating the expression for D, we have

$$dD = r\alpha \cos(\alpha m + c)\, dm + r_{,}\alpha_{,} \cos(\alpha_{,}m + c_{,})\, dm + \dots\dots$$

hence for any time t and for minutes of arc,

$$v = 60 \sin 1^\circ \left[r\alpha \cos(\alpha m + c) + r_{,}\alpha_{,} \cos(\alpha_{,}m + c_{,}) + \dots \right]$$

Maxima and minima are deduced from the equation:

$$0 = r\alpha \cos(\alpha m + c) + r_{,}\alpha_{,} \cos(\alpha_{,}m + c_{,}) + \dots\dots$$

from which expression m can be found.

The apparent probable error e_0 of an observation is deduced from the differences Δ of the n observed and computed declinations by the formula $e_0 = \sqrt{\frac{0.455\ \Sigma\Delta^2}{n - n_{,}}}$, where Σ indicates summation and $n_{,}$ equals the number of unknown quantities in the expression for D, as determined from the observations themselves; when weights p enter, we substitute $p\Delta^2$ for Δ^2 and then obtain the probable error of an observation of unit weight. The greater part of this apparent probable error or rather probable uncertainty in the representation is due to the fact that the observations collected at any one place were not generally made at precisely the same spot, thus introducing the effect of any local irregularities in the distribution of magnetism in addition to the ordinary observing errors. In the case of observations evidently not corrected for dirunal variation, and for which the hour of the day of observation was not known, the received imperfect value had to be accepted; this remark applies more particularly to accurate measures for which alone this correction is of importance.

There are some stations where either from want of a sufficient number of observations, or from shortness of interval between the first and last observation, the length of the period of the secular variation could not be made out. In such cases the declination and *annual change* due to the secular motion may temporarily be expressed by means of an exponential function, thus:

$$D = d_0 + y\,(t - t_0) + z\,(t - t_0)^2 + \dots$$

where d_0 = magnetic declination at epoch t_0. I adopt, as in the preceding formulæ, $t_0 = 1850.0$, and put $d_0 = \delta + x$, where δ = an approximate value of d_0 and x a correction to it to be determined, as well as y and z, etc., from the observations themselves. For this purpose we have a number of conditional equations of the form

$$0 = \delta - D + x + y\,m + z\,m^2 + \dots$$

which equations are to be treated, as customary, by the method of least squares.

Let D = resulting magnetic declination $\left\{ \begin{matrix} + \text{ when west} \\ - \text{ when east} \end{matrix} \right\}$ for the time t

a = annual change $= y + 2z\,(t - t_0) = y + 2z\,.\,m$; also

T = time of maximum declination $= t_0 - \frac{y}{2z}$

In case the change of declination can be represented by a straight line, we have $D = d_0 + a\,(t - t_0)$ and the conditional equation will be of the simple form: $0 = d_0 - D + a\,(t - t_0)$ where d_0 = mean of all observed declinations and t_0 = mean of corresponding times.

The principal uncertainty in the investigation thus arises partly from large observing or instrumental errors in the older observations made with the ordinary compasses or with rude instruments generally, and partly, in case of modern observations, since the introduction of more refined instruments (the magnetometer with collimator magnet and theodolite), from changes in the local positions and from imperfect elimination or irregular variations from the normal direction of the magnet. In consequence of the extended use of iron and steel above and below ground, and the spread of the electric telegraph, telephone, and electric-light wires, combined with the rapid growth of cities extending themselves over the sites of the older stations, it is found difficult to select and preserve at such places a suitable locality for permanent use. Accurate investigations of the secular variation can only be carried out at regular magnetic observatories or in localities permanently exempt from all disturbing influences.

In applying at present a periodic function for the representation of the secular variation,* it should be understood that this *does not necessarily* imply that the phenomenon is a periodic one, or even that it has an invariable period of the length assigned, or that it must exhibit a second motion of like character to the first; it is possible that a whole period may not be completed without some minor change of law. The aim is simply to represent by a suitable and sufficiently comprehensive formula the changes which are observed in the direction of the horizontal component of the magnetic force from year to year and during centuries, and to provide the means for the further investigation of the phenomenon with a view to ascertaining its probable cause, as well as for predicting, at least for a few years in advance, the probable direction of the needle. This last information is required in the construction of our hydrographic and coast charts, for the use of the navigator and for the surveyor.

The analytical process is thus one of a tentative character and the formulæ are necessarily empirical and in need of continual reconstruction and improvement. Employing thus a formula of interpolation capable of representing the phenomenon only as far as observed, it would manifestly be unsafe to extend its numerical results either way much beyond the limits of observation. The predictions are here given within proper and safe limits, and the tabular results should *not* be transgressed in either direction unless the results are sustained by additional observations.

COLLECTION OF OBSERVED MAGNETIC DECLINATIONS SUITABLE FOR THE INVESTIGATION OF THE SECULAR VARIATION.

The material collected for this purpose has been arranged geographically in three groups for greater convenience of reference and of comparison of results. It approximates to an arrangement proceeding from stations of the greatest west declination (at present) to those of greatest east declination, and comprises the whole area of the United States as well as a few foreign localities, which were introduced for the special purpose of preparing the way for geographically extending and connecting the laws of the secular change, so far as they can be made out for North America.

Group I comprises stations mainly on the Atlantic coast of the United States and the region east of the Appalachian range.

In particular, the stations of this eastern series extend from Newfoundland and Eastern Canada along our Atlantic coast as far south as Florida. Added to these are one station in France, one in the Bermuda Islands, and one in Brazil.

Group II includes stations mainly in the central part of the United States, between the Appalachian and Rocky Mountain systems.

In particular, the stations of this central series cover the region south of Hudson Bay and within the United States, including the entire area drained by the Gulf of Mexico. Added to these are two stations in the West Indies and one in Central America.

Group III comprises mainly the Pacific coast stations, and includes the Rocky Mountain region.

In particular, the stations are scattered from the Isthmus of Tehuantepec through the western coast States and Territories, including Alaska. To this group are added one station in Siberia and two in the Sandwich Islands.

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* If we suppose for the moment that the secular variation consists simply of a swing about a mean position, the deflecting force being a maximum at the times of elongation and zero for the epoch midway between, we may obtain some rough evaluation of the magnitude of the horizontal deflecting force when greatest. Thus, at Philadelphia the half-amplitude or the secular deflection either way from the normal equals nearly 3°.3 and the last extreme deflection happened about 1802. At that time, then, the deflecting force corresponded to $\frac{3.3}{57.3}=\frac{1}{17}$ nearly of the normal horizontal force acting in the plane of the meridian. This deflecting force is very much greater than the deflecting force which produces the daily solar variation, the latter being at most, at Philadelphia, for an average amplitude of 8′.0, equal to $\frac{4.0}{3437.7}=\frac{1}{860}$ nearly of the same normal horizontal force.

Each group is treated separately; the record of observations is given first, with such notes appended as seemed demanded for each locality; then follow the analytical formulæ expressing the secular change, next are given the comparisons between observed and computed values, and the statement of results is completed by decennial tabular values of the declination up to the year 1850, after that by computed values given for every fifth year, ending with 1900. A comparison of the results reached in the several editions of this paper shows a gradual improvement of precision, yet much more is expected through future accumulations of data promising results more comprehensive and reliable than can be deduced at present.

GROUP I.—*Series of magnetic stations mainly on the Atlantic coast and in the region east of the Appalachian range.*

The stations of this eastern series are irregularly distributed over the region between Newfoundland and Florida, with one station each, in France, in the Bermudas, and Brazil.

Observations were collected and discussed for secular change of declination at the following places, arranged in the order of decreasing latitudes:

1. Saint John's, Newfoundland.
2. Quebec, Canada.
3. Charlottetown, Prince Edward Island.
4. Montreal, Canada.
5. Eastport, Me.
6. Bangor, Me.
7. Halifax, Nova Scotia.
8. Burlington, Vt.
9. Hanover, N. H.
10. Portland, Me.
11. Rutland, Vt.
12. Portsmouth, N. H.
13. Chesterfield, N. H.
14. Newburyport, Mass.
15. Williamstown, Mass.
16. Albany, N. Y.
17. Salem, Mass.
18. Oxford, N. Y.
19. Cambridge, Mass.
20. Boston, Mass.
21. Provincetown, Cape Cod, Mass.
22. Providence, R. I.
23. Hartford, Conn.
24. New Haven, Conn.
25. Nantucket, Mass.
26. Cold Spring Harbor, Long Island, N. Y.
27. New York, N. Y.

... Tyrone, Pa.

28. Bethlehem, Pa.
29. Huntingdon, Pa.
30. New Brunswick, N. J.
31. Jamesburg, N. J.
32. Harrisburg, Pa.
33. Hatboro', Pa.
34. Philadelphia, Pa.
35. Chambersburg, Pa.
36. Baltimore, Md.
37. Washington, D. C.
38. Cape Henlopen, Del.
39. Williamsburg, Va.
40. Cape Henry, Va.
41. New Berne, N. C.
42. Milledgeville, Ga.
43. Charleston, S. C.
44. Savannah, Ga.
45. Paris, France.
46. Saint George's Town, Bermuda Islands.
47. Rio de Janeiro, Brazil.

The first column of the record for any station contains the running number of the observed values made use of in the discussion; the second, the date of the observation; the third, the observed value; and the fourth, the name of the observer, the geographical position of the station, the reference to publication, and other pertinent remarks. Unless otherwise stated, unit weight $w = 1$) is given to each observation in the computation.

GROUP I.—*Collection of observed Magnetic Declinations, Eastern Series.*

1.—SAINT JOHN'S, NEWFOUNDLAND.

$\phi = 47° 34'.4$ $\lambda = 52° 41'.9$ W. of Gr.

(Government House.)

		° '	
1	1630, about.	15 W.	R. Dudley's Arcano del Mare, Florence, 1646–47. [$w = \frac{1}{4}$.—SCH.]
2	1700--	15	Edm. Halley's Tabula Nautica; Variationum Magneticarum index, etc., 1700. Greenwich astro'l observations, 1869. [Auxiliary value, $w = \frac{1}{2}$.—SCH.]
3	1750--	17¾	A rough auxiliary value depending on observations about this period; see C. and Geod. Survey Bulletin No. 6. [$w = \frac{1}{2}$.—SCH.]
4	1787--	16	E. Walker's "Terrestrial and Cosmical Magnetism," Cambridge, 1866, plate 7, according to Hansteen. [Auxiliary value, $w = \frac{1}{4}$.—SCH]
5	1833--	26 30	P. Barlow's isogonic chart. in Phil. Trans. Roy. Soc., 1833, pt. I, p. 668.
6*	1844, October.	29 36	Capt. Bayfield, R. N.; in Phil. Trans. Roy. Soc., 1849, p. 211.
7*	1857, July.	31 21	Capt. Dayman, R. N.; account of deep-sea soundings in the North Atlantic Ocean, 1858, p. 61.
8*	1862, September 11.	31 20	Capt. Orlebar, R. N.
9*	1863, September 22.	31 18	Capt. Orlebar, R. N.
10*	1864, June 3.	31 00	Capt. Orlebar, R. N.
11*	1866, April to October.	30 55	Near Government House.
12	1881, June 29	30 26	Lieut. C. P. Perkins, U. S. S. Alliance; in $\phi = 47° 34'$, $\lambda = 52° 35'$.W. Naval Professional Papers No. 19, Washington, 1886.
12	1881, September 26, 27, 28.	30 37.3 W.	Lieut. S. W. Very, N. S. N., Asst. Coast and Geod. Survey. In N. W. corner of grounds surrounding the Government House. [Mean value $+30°.52$ for 1881.6; the weight 2 was given to this value.—SCH.]

2.—QUEBEC, CANADA.

$\phi = 46° 48'.4$. $\lambda = 71° 14'.5$ W. of Gr.

(Wolfe's Monument.)

		° '	
1	1642--	16 W.	Padre Bressani; Hansteen's Magnetismus der Erde, 1819; also Trans. of the Lit. and Hist. Society of Quebec, 1865.† [Hansteen's date, 1649, changed to 1642, according to President Langton's art. X of Trans. The weight 0.5 is given to this value.—SCH.]
2	1886--	15½	De Hayes; Hansteen's Mag. der Erde, 1819.
3	1700--	16 16½	Edm. Halley's isogonic chart for 1700, Greenwich observations for 1869. A rough auxiliary value; see C. and Geod. Survey Bulletin No. 6. [Mean 16°.25—SCH.]
4	1750--	12½	A rough auxiliary value depending on observations about this period; see C. and Geod. Survey Bulletin No. 6.
5	1785--	12 35	Surveyor-General Holland; E. T. Fletcher in Trans. of the Lit. and Hist. Soc. of Quebec, 1865, art. ix.
6	1789, June 30.	11 45	Louis Perrault, P. L. S.; reference as above.
7	1791, June 22.	13 00 W.	Pierre Beaupré, P. L. S.; reference as above.

* The information for the years marked by an asterisk was communicated to the office by Staff-Commander F. J. Evans, Hydrographer to the British Admiralty.

† I am indebted to Mr. Marcus Baker, of the Computing Division, Coast and Geodetic Survey, for pointing out and procuring this volume for me.

Collection of Magnetic Declinations, etc.—Continued.

QUEBEC, CANADA—Continued.

		° ′		
8	1792, March 24.	12 15	W.	J. B. Demers, P. L. S. } Reference as above. [Mean+12°.42 for 1792.3—SCH.]
	1792, May 9.	13 09		A. Dezery, P. L. S.
	1792, May 16.	12 00		Ch. Turgeon, P. L. S.
	1792, May 16.	12 15		Fr. Legendre, P. L. S.
9	1793--	12 05		Surveyor-General Holland. } Reference as above. [Mean+12°.54 for 1793.6—SCH.]
	1793, November 19.	13 00		J. C. Antill, P. L. S.
10	1805, April.	11 35		Reg. A, folio 117, Dept. of Crown Lands; reference as above.
11	1810--	11 00		Becquerel's Traité du Magnétisme, Paris, 1846.
	1810, June 5.	12 15		Reg. A, folio 131; E. T. Fletcher, Trans. Lit. and HistSoc. of Quebec, 1865. [Mean+11°.62 for 1810.5—SCH.]
12	1811, June.	12 15		Reg. A, folio 143; reference as above.
13	1814--	11 50		Kent, Becquerel's Traité du Magnétisme, Paris, 1846.
14	1820, October 2.	12 30		Bourdages, P. L. S.; E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865.
	1820, November.	12 35		Livingstone, P. L. S.; reference as above. [Mean+12°.54 for 1820.8—SCH.]
15	1821, August 25.	12 15		Jno. McNaughton, P. L. S. } Reference as above. [Mean+12°.90 for 1821.7—SCH.]
	1821, September.	13 00		A. Cattanach, P. L. S.
	1821, September.	13 00		W. Ware, P. L. S.
	1821, November 28.	13 20		E. Tetu, P. L. S.
16	1822, January 21.	13 00		Jos. Hamel, P. L. S. } Reference as above.
	1822, January 21.	13 00		Ph. Verrault, P. L. S.
	1822, April 26.	13 00		P. J. Bureau, P. L. S.
	1822, May.	13 00		Reg. A, folio 162½.
17	1823, March 26.	13 00		N. Le François, P. L. S. } Reference as above.
	1823, May 12.	13 00		D. S. Ballantyne, P. L. S.
	1823, October 3.	13 00		Jos. Gamahe, P. L. S.
	1823, October 23.	13 00		A. Bochet, P. L. S.
	1823, November 14.	13 00		L. Dorval, P. L. S.
18	1824, March 2.	12 40		A. Cattanach, P. L. S.; reference as above.
19	1831--	13 38		Captain Bayfield, Becquerel's Traité du Magnétisme, Paris, 1846.
	1831, July 20.	13 10		Thom. Carrol, P. L. S. } E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865. [Mean+13°.40 for 1831.7—SCH.]
	1831, autumn.	13 00		Jos. Hamel, P. L. S.
	1831, September 6.	14 00		H. Corey, P. L. S.
	1831, December 10.	13 12		John Newman, P. L. S.
20	1832, May.	13 00		Reg. B, fol. 36; reference as above.
21	1833, May.	12 30		Reg. B, fol. 43. } Reference as above. [Mean+12°.75 for 1833.5—SCH.]
	1833, July.	13 00		Reg. B, fol. 43.
22	1834--	14 14		Capt. Bayfield; Trans. Roy. Soc., June, 1872; Gen. Sir. Edw. Sabine, Conts. to Terr. Mag., No. xiii.
	1834, March 10.	13 00		Reg. A, fol. 197. } E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865. [Mean+13°.31 for 1834.4—SCH.]
	1834--	13 00		Reg. B, fol. 61.
	1834, July.	13 00		Reg. B, fol. 69.
23	1835, December.	13 10		Reg. B, fol. 85; reference as above.
24	1838 and 1839.	13 00		Reg. B, fol. 66. } Reference as above. [Mean+13°.37 for 1839.3—SCH.]
	1839, May.	13 30		Reg. B, fol. 144.
	1839--	13 35	W.	Reg. B, fol. 154.

Collection of Magnetic Declinations, etc.—**Continued.**

QUEBEC, CANADA—Continued.

		° ′	
25	1840, May 20.	13 50 W.	R. M. Moore, P. L. S. Reference as above. [Mean +13°.71 for 18405—SCH.]
	1840, September 14.	13 35	Procès-Verbal, by Jos. Bouchette, D. S. G.
26	1842, December 7.	13 50	Reg. B, fol. 281., Anse des Mères; reference as above. [Mean +14°.02 for 1842.7—SCH.]
	1842..	14 12	Capt. J. H. Lefroy, R. E.; Phil. Trans. Roy. Soc., 1849, part II.
27	1846..	14 32	Reg. B, fol. 318, La Canardière; E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865.
28	1847, September 17.	15 30	Reg. B, fol. 316. Reference as above. [Mean +14°.64 for 1847.7.—SCH.]
	1847, September 20.	14 45	Reg. B, fol. 262.
	1847, October 13.	13 40	Reg. B, fol. 269.
29	1848, February.	15 15	Reg. B, fol. 277. Reference as above. [Mean +14°.58 for 1848.5—SCH.]
	1848, June 28.	14 00	Reg. B, fol. 299.
	1848, October.	14 30	N. Le François, P. L. S., Field-Book C, 50.
30	1849, March 8.	15 30	Reg. B, fol. 316. Reference as above. [Mean +15°.37 for 1849.4.—SCH.]
	1849, July 8.	15 15	Reg. C, fol. 5.
31	1850, April.	15 15	Reg. C, fol. 13; reference as above.
32	1851, autumn.	15 00	Reg. C, fol. 33; reference as above.
33	1853, January 19.	15 30	Reg. B, fol. 320; reference as before.
34	1858, October 8.	15 34	Capt. Orlebar, R. N.; communicated by Capt. F. J. Evans, Hydrographic Dept., Admiralty, London.
35	1859, July 19.	16 17	C. A. Schott, Asst. Coast Survey; station near Wolfe's Monument. Coast Survey Report for 1859, p. 296, ϕ and λ as in heading.
36	1860, October 12.	16 28	Capt. Orlebar, R. N.; communicated by Capt. F. J. Evans, Admiralty, London. [This value received double weight.—SCH.]
37	1865..	16 40	E. T. Fletcher, surveyor to Dept. of Crown Lands. [This value was given double weight.—SCH.]
38	1879, September 16, 19.	17 13.7 W.	J. B. Baylor, U. S. Coast and Geodetic Survey, in $\phi=46° 48'.4$, $\lambda=71° 14'.5$ W.; station of 1859, Coast and Geodetic Survey Report for 1881, App. No. 9. [This value was given double weight.—SCH.]

3.—CHARLOTTETOWN, PRINCE EDWARD ISLAND.

$\phi=46° 14'$ $\lambda=63° 27'$ W. of Gr.

		° ′	
1	1833..	19 30 W.	Peter Barlow's isogonic chart for 1833, Phil. Trans. Roy. Soc., 1833, pt. i, p. 668.
2	1842, June.	21 03	Capt. Bayfield, R. N. Letter of Staff-Comdr. J. F. Evans of Jan. 5, 1866; see also Phil. Trans. Roy. Soc., 1849, p. 211.
3	1857, May.	23 02	Capt. Orlebar, R. N. Reference as above.
4	1858, May 18.	22 54	
5	1859, May 20.	22 51	
6	1860, May 17.	22 50	
7	1861, May 14.	22 45	
8	1862, May 27.	23 19	
9	1883, August 29.	24 02	Lieut. J. C. Rich, U. S. S. Alliance; in $\phi=46° 10'$, $\lambda=62° 18'$ W. Naval Professional Papers No. 19, Washington, 1886.
	1883, September 22.	24 19 W.	Lieut. R. B. Peck, U. S. S. Swatara; in $\phi=46° 10'$, $\lambda=62° 27'$ W. Reference as above. [Mean 24° 10'.5 W., reduction to town—45'; hence decl'n $=23° 26'$ W.—SCH.]

Collection of Magnetic Declinations, etc.—Continued.

4.—MONTREAL, CANADA.

$\phi = 45^\circ 30'.5$ $\lambda = 73^\circ 34'.6$ W. of Gr.

(College Observatory, McGill University.)

		° ′	
1	1700..	$14\frac{3}{4}$ W.	A rough auxiliary value, depending on observations about this period; see C. and Geod. Survey Bulletin No. 6.
2	1749..	10 38	M. Gillion. V. Colvin, Sup't Adirondack Survey, N. Y., 7th Annual Report, Albany, 1880, p. 492.
	1750..	10.3	A rough auxiliary value, depending on observations about this period, see C. and Geod. Survey Bulletin No. 6. [Not used.—SCH.]
3	1785..	8 24	Holland, Surv. Gen. of Canada. V. Colvin, Sup't Adirondack Survey, N. Y., 7th Annual Report, Albany, 1880, p. 492.
4	1793, July 26.	8 15	Jer. McCarthey, Trans. Lit. and Hist. Soc. of Quebec, session of 1864–'65, new series; Quebec, 1865, p. 3.
5	1814..	7 45	Becquerel's Traité du Magnétisme, Paris, 1846.
6	1834..	8 00	Capt. Bayfield; Gen. Sir Edw. Sabine's Conts. No. ix, Phil. Trans. Roy. Soc., 1849; in $\phi = 45^\circ 32'$, $\lambda = 73^\circ 34'$ W.
7	1835..	9 50	Reference as for Nos. 2 and 3.
8	1842, August.	8 57.6	Capt. J. H. Lefroy, R. E. Coast Survey Report for 1855, p. 304. Gen. Sir J. H. Lefroy's Diary of Magnetic Survey, Canada, etc., London, 1883.
9	1859, July 20.	12 21	C. A. Schott, asst. Coast Survey; Coast and Geodetic Survey Report for 1881, App. No. 9. Grounds of McGill University in $\phi = 45^\circ 30'.5$, $\lambda = 73^\circ 34'.6$ W.
10	1879, September 25.	13 40.5 W.	J. B. Baylor, Coast and Geodetic Survey. Grounds of McGill University. Report for 1881, App. No. 9.

5.—EASTPORT, ME.

$\phi = 44^\circ 54'.4$ $\lambda = 66^\circ 59'.2$ W. of Gr.

(Fort Sullivan.)

		° ′	
1	1604–1612.	17 32 W.	Champlain's observation at Douchet Island, St. Croix River. [Information received from asst. H. Mitchell, May 4, 1877, $w = \frac{1}{3}$.—SCH.]
	1630, about.	13.4	R. Dudley's Arcano del Mare, Florence, 1646–'47. [Not used.—SCH.]
2	1700..	{ 13 13.3	{ Edm. Halley's isogonic chart, Tabula Nautica; Variationum Magneticarum index, etc., 1700. Greenwich astronomical observations, 1869. [Auxiliary value, 13°.03, according to my discussion of observations about this period, see C. and Geod. Survey Bulletin No. 6, $w = \frac{1}{2}$.—SCH.]
3	1750..	11.4	An auxiliary value, same reference as above. [$w = \frac{1}{2}$.—SCH.]
4	1775..	12 40	At Grand Manan Island; Des Barres's, Atlantic Neptune, London, 1781.
5	1797..	12 19	From a chart, at the mouth of St. Croix, in $\phi = 45^\circ 05'$, $\lambda = 67^\circ 12'$ W. Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838. [Reduction to Eastport about $-5'$.—SCH.]
6	1833..	14 30	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., 1833. [$w = \frac{1}{2}$.—SCH.]
	1857, September 16–19.	15 21.1 W.	G. W. Dean, asst. Coast Survey; at Calais, in $\phi = 45^\circ 11'.1$, $\lambda = 67^\circ 16'.8$ W. Coast Survey Report for 1858, p. 191. [Reduction to Eastport $-12'$, not used.—SCH.]

Collection of Magnetic Declinations, etc.—Continued.

EASTPORT, ME.—Continued.

		° ′		
7	1860, August to December.	17 57.1 W.	G. B. Vose	Coast Survey observers; at the Fort Sullivan Magnetic Observatory. Coast and Geodetic Survey Report for 1881, App. 9. $\phi=44° 54'.4$, $\lambda=66° 59'.2$ W.
8	1861, January to December.	17 59.2	G. B. Vose and S. Walker	
9	1862, January to December.	18 00.6	S. Walker, R. H. Talcott, E. Goodfellow	
10	1863, January to December.	18 02.3	E. Goodfellow	
11	1864, January to July incl.	18 03.7	E. Goodfellow, A. T. Mosman, H. W. Richardson	
12	1865, July 22–25.	18 06.1	H. W. Richardson	
13	1873, September 2, 3.	18 56.0	Dr. T. C. Hilgard, observer for Coast Survey; at Fort Sullivan, in $\phi=44° 54'.3$, $\lambda=66° 59'.3$ W. Reference as above.	
14	1879, August 27, 28.	19 07.8	J. B. Baylor, U. S. Coast and Geodetic Survey; at station of 1860. Reference as before.	
15	1887, August 24, 26.	18 35.2 W.	J. B. Baylor, asst. Coast and Geod. Survey; at parade ground. Fort Sullivan. MS. in archives.	

6.—BANGOR, ME.

$\phi=44° 48'.2$ $\lambda=68° 46'.9$ W. of Gr.

(Thomas Hill.)

		° ′	
1	1805	11 15 W.	J. Herrick, at Hampden, in $\phi=44° 44'$, $\lambda=68° 50'$. Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
2	1837	13 04	J. Herrick, position and reference as before.
3	1840	13 22	Hon. N. Barker, Commissioner; at Hampden. Pamphlet by I. E. Getchell, North Vassalboro', 1880.
4	1844, June to October, incl.	14 29	W. P. Parrott & S. Nott; at Bangor, in $\phi=44° 48'$, $\lambda=68° 46'$. MS. presented to the Survey by S. Nott, May 30, 1888. Observations made almost daily, and generally at three stated hours. [Observations reduced to mean of day by myself.—Sch.]
5	1857, October 13, 14, 15.	15 19.9	G. W. Dean, asst. Coast Survey; on Thomas Hill, near and south of astronomical station. Position as in heading.
6	1879, August 21.	16 29.3 W.	J. B. Baylor, sub-asst., C. and Geod. Survey, at Bangor, on Thomas Hill, in $\phi=44° 48'.2$, $\lambda=68° 46'.9$, near astronomical stattion of 1851 and 1857. MS. in archives.

7.—HALIFAX, NOVA SCOTIA.

$\phi=44° 39'.6$ $\lambda=63° 35'.3$ W. of Gr.

(Naval Yard Observatory.)

		° ′	
1	1604–1612.	16¼ W.	According to Champlain's observations at Cape Breton, in Nova Scotia and New Brunswick. At Cape La Have, the station nearest to Halifax, he observed 16° 15′ W., in $\phi=44° 11'$, $\lambda=64° 15'$ W. Trans. Lit. and Hist. Soc. of Quebec, session 1864–'65, John Langton, president; Quebec, 1865. [$w=\frac{1}{2}$.—Sch.]
2	1630, about.	14	R. Dudley's Arcano del Mare, Florence, 1646–'47. [$w=\frac{1}{2}$.—Sch.]
3	1700	13	Edm. Halley's Tabula Nautica; Variationum Magneticarum index, &c., 1700; Greenwich astro'l observations, 1869. [Auxiliary value.—Sch.]
		12¼ W.	A rough auxiliary value depending on observations about this period; see C. and Geod. Survey Bulletin No. 6. [Mean, 12°.75; $w=\frac{1}{2}$.—Sch.]

Collection of Magnetic Declinations, etc.—**Continued.**

HALIFAX, NOVA SCOTIA—Continued.

		° ′	
4	1750..	12 W.	A rough auxiliary value depending on observations about this period; see C. and Geod. Survey Bulletin No. 6. [$w=\frac{1}{2}$.—SCH.]
5*	1756..	12 50	From a MS. map by Charles Morris, asst. surveyor.
6*	1775..	13 35	Des Barres's sailing directions.
7*	1798..	16 30	Plan of Halifax, published by Thomas Backhouse.
8*	1818(?).	17 28	Remark book of J. Napier, master R. N.; as given by Anthony Lockwood.
9*	1821, June to November.	17 36	Observer as above; observation in June, 17° 38′.2 W.; in Nov., 17° 33′.5 W.
10	1833..	17 30	Peter Barlow's isogonic chart for 1833 in Phil. Trans. Royal Soc., 1833, pt. i, p. 668.
11*	1852–53.	18 10	Capt. Bayfield, magnetic survey.
12*	1852–53.	18 51	Remark book by J. Hill, master R. N., viz, Aug., 1852, 18° 46′ W.; Sept., 1852, 19° 21′ W., and Aug., 1853, 18° 25′ W. [We adopt, for 1852.7, the mean value 18° 46′ W., and for 1853.2, the value 18° 51′ W.]
13*	1860, July 22.	19 55	Capt. Orlebar, R. N.
14*	1866, April.	21 05.6	Halifax Dock Yard, in $\phi=44°\ 40'$, $\lambda=63°\ 25'$ W.; declination April 1, at 9 a. m., 20° 55′.0 W.; on April 3, at 3 p. m., 21° 16′.3 W. [$w=2$.—SCH.]
15	1873, May 15.	21 35	H. M. S. Challenger, at Drill ground, Dock Yard, in $\phi=44°\ 39'.8$, $\lambda=63°\ 35'.2$ W. Report on the scientific results of the voyage of H. M. S. Challenger, etc. Narrative, Vol. II. London, 1882, pp. 26 and 46.
16	1879, September 8, 10.	20 43.3 W.	J. B. Baylor, United States Coast and Geodetic Survey, at southeast end of Dock Yard, in $\phi=44°\ 39'.5$, $\lambda=63°\ 35'.0$ W. Coast and Geodetic Survey Report for 1881, Appendix No. 9. [$w=2$.—SCH.]

8.—BURLINGTON, VT.

$\phi=44°\ 28'.5$ $\lambda=73°\ 12'.0$ W. of Gr.

(Coast Survey astronomical station.)

		° ′	
1	1793..	7 38 W.	Dr. Williams; in $\phi=44°\ 28'$, $\lambda=73°\ 14'$ W.; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838.
2	1805..	6 12	J. Johnson, in Thompson's History of Vermont. From repeated comparisons, declination believed by him to be a minimum at this time. [Weight ½ given to this value.—SCH.]
3	1818..	7 30	J. Johnson } Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838; in $\phi=44°\ 28'$, $\lambda=73°\ 14'$ W.
4	1822..	7 42	J. Johnson
5	1826..	7 36	Prof. G. W. Benedict; in $\phi=44°\ 27'$, $\lambda=73°\ 10'$ W.; Prof. E. Loomis's collection in Sill. Jour., vol. xxxix, 1840.
6	1830..	8 10	J. Johnson } Prof. E. Loomis's collection, Sill. Jour., vol. xxxiv, 1838.
7	1831..	8 15	J. Johnson
8	1832..	8 25	J. Johnson
9	1834..	8 50	J. Johnson
	1837..	9 45	Prof. G. W. Benedict; Thompson's History of Vermont. [Perhaps a misprint for 8° 45′; not used.—SCH.]
10	1840..	9 42 W.	J. Johnson; Thompson's History of Vermont.

* Observations marked by an asterisk were communicated to the Survey by Staff-Commander Fred. John Evans, R. N.; letters dated January 5, 1886, and April 26, 1887.

Collection of Magnetic Declinations, etc.—**Continued.**

BURLINGTON, VT.—Continued.

		° ′	
11	1845, June 26.	9 22 W.	Dr. J. Locke; in ϕ=44° 27′, λ=73° 10′ W.; Smithsonian Contributions to Knowledge, vol. iii, 1852.
12	1855, August 28.	9 57.1	C. A. Schott, asst. Coast Survey; at encampment flag-staff near the lake shore, in ϕ=44° 29′.3, λ=73° 13′.4 W.; Coast Survey Report for 1855, p. 337.
13	1870, November 12.	10 57	G. A. Marr, west of cemetery, in ϕ=44° 30′, λ=73° 12′. Prof. Papers U. S. Eng's No. 24, 1882.
14	1873, October 14, 15.	11 19.0 W.	Dr. T. C. Hilgard, observer for U. S. Coast Survey; in ϕ=44° 28′.2, λ=73° 12′.3; Coast and Geodetic Survey Report for 1881, App. 9.

9.—HANOVER, N. H.

ϕ=43° 42′.3 λ=72° 17′.1 W. of Gr.

(Dartmouth College Observatory.)

		° ′	
1	1765..	7 0 W.	According to President Wheelock, in ϕ=43° 41′, λ=72° 10′ W.; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838.
2	1810..	4 15	President Wheelock; reference as above.
3	1839..	9 15	Prof. C. A. Young, in ϕ=43° 42′, λ=72° 10′ W.; Prof. E. Loomis's collection in Sill. Jour., vol. xxxix, 1840.
4	1855, September 18.	10 27	J. M. Clark, at West Hartford, Vt., in ϕ=43° 42′, λ=72° 22′.
5	1873, October 4–11.	10 49.6	Dr. T. C. Hilgard, observer for U. S. Coast Survey; near observatory; Coast and Geodetic Survey Report for 1881, App. 9.
6	1876, August 3, 5.	11 05.3	F. E. Hilgard, at White River Junction, Vt., in ϕ=43° 40′, λ=72° 18′. National Academy Series. C. and Geod. Survey Report for 1882.
	1879, October 6.	10 50.5	J. B. Baylor, Coast and Geodetic Survey. This station was the same as that of 1873, a little north of observatory. [Not used.—SCH.]
7	1879, October 7.	11 38.4 W.	Same observer; at a station three-quarters of a mile west of Observatory Hill, in ϕ=43° 42′.3, λ=72° 18′.0 W.; Coast and Geodetic Survey Report for 1881, App. 9.

10.—PORTLAND, ME.

ϕ=43° 38′.8 λ=70° 16′.6 W. of Gr.

(Bramhall Hill.)

		° ′	
	1604–1612	19 12 W.	Champlain's observations at the mouth of the Kennebec River. [Not used.—SCH.]
	1630, about.	12½	R. Dudley's Arcano del Mare, Florence, 1646–'47. [Not used.—SCH.]
1	1700..	12.4	Edm. Halley's isogonic chart, Tabula Nautica, etc.; Greenwich astronomical observations, 1869.
		11.8	A rough auxiliary value depending on observations about this period; see C. and Geod. Survey Bulletin No. 6. [Mean + 12°.1—SCH.]
2	1750..	9.2	A rough auxiliary value depending on observations about this period; see C. and Geod. Survey Bulletin No. 6.
3	1763..	7 45 W.	Prof. John Winthrop; at Falmouth, in ϕ=43° 39′, λ=70° 19′ W. Sill. Jour., vol. xvi, 1829; see also Prof. E. Loomis's remarks on the Winthrop table, in Sill. Jour., vol. xxxiv, 1838.

Collection of Magnetic Declinations, etc.—Continued.

PORTLAND, ME.—Continued.

		° ′	
4	1775--	8 30 W.	J. F. W. Des Barres's Atlantic Neptune, London, 1781.
	1833--	10 00	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., 1833. [Not used.—SCH.]
5	1845, June 4.	11 28.3	Dr. J. Locke, in φ=43° 41′, λ=70° 20′ W.; Smithsonian Contributions to Knowledge, vol. iii, 1852.
6	1851, August 18, 20.	11 41.1	J. E. Hilgard, asst. Coast Survey; at Bramhall Hill, in ϕ=43° 38′.8, λ=70° 16′.6 W.; Coast Survey Report for 1854, p. 143.
7	1859, July 15.	12 20	C. A. Schott, asst. Coast Survey; at Bramhall Hill; Coast Survey Report for 1859, p. 296.
	1863, July 6.	12 18.1	C. A. Schott, asst. Coast Survey; at Mount Joy Observatory, in ϕ=43° 39′.9, λ=70° 14′.9 W.; Coast Survey Report for 1863, p. 204. [Not used.—SCH.]
8	1863, July 15.	12 28.2	C. A. Schott, asst. Coast Survey; at Bramhall Hill, near station of 1859; Coast Survey Report for 1863, p. 204.
9	1864, August to December.	12 43.7	Prof. H. W. Richardson, observer for U. S. Coast Survey; at Bramhall Hill; monthly determinations on four days each; Coast and Geodetic Survey Report for 1881, App. No. 9.
10	1865, January to December.	12 42.3	
11	1866, January to March incl.	12 42.9	
12	1873, September 8, 9, 11.	12 43.6	Dr. T. C. Hilgard, observer for U. S. Coast Survey; near Mount Joy Observatory; reference as above. [To refer to Bramhall station, add 10′.—SCH.]
13	1887, October 14, 15.	13 51.0 W.	J. B. Baylor, asst. C. and Geod. Survey; at Bramhall station. MS. in archives.

11.—RUTLAND, VT.

ϕ=43° 36′.5 λ=72° 55′.5 W. of Gr.

(Post-office.)

		° ′	
1	1789, April.	7 03 W.	Dr. Williams; Sill. Jour., vol. xvi, 1829. [Weight, ½ assigned.—SCH.]
2	1810, May.	6 04	
3	1811, September.	6 01	
4	1859, July 21.	9 49	C. A. Schott, asst. Coast Survey; near new post-office; Coast Survey Report for 1859, p. 296.
5	1873, October 17, 18.	10 40.2	Dr. T. C. Hilgard, observer for U. S. Coast Survey; Coast and Geodetic Survey Report for 1881, App. 9.
6	1879, October 14, 15.	11 09.0 W.	J. B. Baylor, Coast and Geodetic Survey; station of 1873, north and west of post-office, in ϕ=43° 36′.5, 72° 55′.5 W.; reference as before.

12.—PORTSMOUTH, N. H.

ϕ=43° 04′.3 λ=70° 42′.5 W. of Gr.

(New Castle Light-house.)

		° ′	
1	1771--	7 46 W.	Holland, at Kittery, Me., opposite Portsmouth, in ϕ=43° 06′, λ=70° 45′ W.; Prof. E Loomis's collection in Sill. Jour., vol. xxxiv, 1838.
	1771--	7 48	Holland, in ϕ=43° 05′, λ=70° 45′; reference as above. [Not used.—SCH.]
2	1775--	7 45	J. F. W. Des Barres's Atlantic Neptune, London, 1781.
3	1833--	8 45 W.	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., 1833.

Collection of Magnetic Declinations, etc.—Continued.

PORTSMOUTH, N. H.—Continued.

		° ′	
4	1844-45.	9 47 W.	Major Graham; at Boiling Rock; Gen. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., 1872; in $\phi=43° 05'$, $\lambda=70° 45'$ W.
5	1850, August 28, September 2.	10 30.2	J. E. Hilgard, asst. Coast Survey; at Kittery Point, Me.; Coast Survey Report for 1854, p. 143.
6	1859, July 14.	11 15.0	C. A. Schott, asst. Coast Survey; at Kittery Point, Me.; Coast Survey Report for 1859, p. 296.
7	1879, August 13, 14.	12 31.3 W.	J. B. Baylor, U. S. Coast and Geodetic Survey; station of 1850 and 1859, in $\phi=43° 04'.8$, $\lambda=70° 43'.0$ W. of Gr.; Coast and Geodetic Survey Report for 1881, App. 9.

13.—CHESTERFIELD, N. H.

$\phi=42° 53'.5$ $\lambda=72° 24'$ W. of Gr.

		° ′	
1	1812..	6 26 W.	Nathan Wilde, observer; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838; position assigned $\phi=42° 53'$, $\lambda=72° 20'$ W.
2	1813..	6 25	
3	1814..	6 17	
4	1815..	6 07	
5	1816..	6 03	
6	1817..	6 02	
7	1818..	6 00	
8	1819..	6 03	
9	1820..	6 00	
10	1821..	6 07	
11	1822..	6 12	
12	1823..	6 30	
13	1824..	6 40	
14	1825..	6 35	
15	1826..	6 35	
16	1827..	6 45	
17	1828..	6 52	
18	1829..	7 00	
19	1830..	7 06	
20	1831..	7 10	
21	1832..	7 15	
22	1833..	7 30	
23	1834..	7 35	
24	1835..	7 40	
25	1836..	7 45	
26	1837..	8 05	A. C. Twining; reference as above.
27	1874, October 4.	10 26.6 W.	Dr. T. C. Hilgard, observer for Coast Survey; in $\phi=42° 54'.0$, $\lambda=72° 26'.0$ W.; Coast and Geodetic Survey Report for 1881, App. 9.

Collection of Magnetic Declinations, etc.—Continued.

14.—NEWBURYPORT, MASS.

$\phi=42° 48'.9$ $\lambda=70° 49'.2$ W. of Gr.

(From Island Light.)

		° ′	
1	1750--	8 14 W.	A rough auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6. [$w=\frac{1}{2}$.—SCH.]
2	1775--	6 45	J. F. Des Barres's Atlantic Neptune, London, 1781; north of Cape Ann, opposite Newburyport.
3	1781--	7 18	Dr. Williams, in $\phi=42° 48'$, $\lambda=70° 52'$ W. Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838.
4	1833--	8 30	Peter Barlow's isogonic chart for 1833. Phil. Trans. Roy. Soc. for 1833.
5	1850, September 18-20.	10 05.6	J. E. Hilgard, asst. Coast Survey; on Plum Island, in $\phi=42° 48'.0$, $\lambda=70° 48'.8$ W. Coast Survey Report for 1854, p. 143.
6	1859, July 13.	10 58.0	C. A. Schott, asst. Coast Survey; same position as in 1850. Coast Survey Report for 1859, p. 296.
7	1887, October 19, 20.	12 11.9 W.	J. B. Baylor. asst. C. and Geod. Survey; position as before. MS. in archives.

15.—WILLIAMSTOWN, MASS.

$\phi=42° 42'.8$ $\lambda=73° 13'.4$ W. of Gr.

(Astronomical Observatory.)

		° ′	
1	1750--	7 32 W.	A rough auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6. [$w=\frac{1}{2}$.—SCH.]
2	1786--	5 52	Dr. Williams; Prof. E. Loomis's collection, Sill. Jour., vol. xxxiv, 1838.
3	1833--	6 15	Prof. A. Hopkins; Prof. E. Loomis's collection, Sill. Jour., vol. xxxix, 1840.
4	1837--	7 45	Prof. A. Hopkins; reference as before.
5	1876, July 28, 29.	10 30.8	F. E. Hilgard, at North Adams, about 4 miles east of Williamstown; in $\phi=42° 42'$, $\lambda=73° 08'$ W.; National Academy series, Coast and Geodetic Survey Report for 1882, App. 14.
6	1886, August 22.	10 21 W.	A. Walker and Prof. T. H. Safford; southern part of meridian line of Williamstown College, in $\phi=42° 42'.8$, $\lambda=73° 13'.4$ W.; letter of A. Walker, dated Sept. 25, 1886.

16.—ALBANY, N. Y.

$\phi=42° 39'.2$ $\lambda=73° 45'.8$ W. of Gr.

(State Capitol.)

		° ′	
1	1817, October.	5 44 W.	S. De Witt, surveyor-general; in $\phi=42° 39'$, $\lambda=73° 44'$ W. Sill. Jour., vol. xvi, 1829.
2	1818, August 1.	5 45	
3	1825, April 24.	6 00	
4	1828--	6 14	Geological Report, State of New York, and Sill. Jour., vol. xxxix, 1840.
	1828, September 20.	6 16	
	1828, September 22.	6 18	
5	1830, June 14.	6 18	
6	1831, May 5.	6 25	
	1831--	6 32	
	1831, November 5.	6 40 W.	Regents' Report.

Collection of Magnetic Declinations, etc.—Continued.

ALBANY, N. Y.—Continued.

		° ′	
7	1834, October 1.	6 40 W.	Regents' Report and Sill. Jour., vol. xxxiv, 1838.
8	1836, October 29.	6 47	
9	1847, November.	7 35	Regents' Report.
10	1855, August 31.	7 54.7	C. A. Schott, assistant Coast Survey; at Greenbush, opposite Albany, in $\phi=42^\circ 37'.5$, $\lambda=73^\circ 44'.3$ W. Coast Survey Report for 1855, p. 337.
11	1856, September 1.	8 39.2	Karl Friesach, Berichte der Kais. Kön. Akad., Vienna, vol. 29, 1858. [When corrected for diurnal variations, $+8^\circ 35'$.—Sch.]
12	1858, May 12, 13, 14.	8 17.0	G. W. Dean, asst. Coast Survey, at Dudley Observatory, in $\phi=42^\circ 39'.8$, $\lambda=73^\circ 45'.0$. Coast and Geodetic Survey Report for 1881, Appendix 9.
13	1879, October 21, 24.	9 51.7 W.	J. B. Baylor, U. S. Coast and Geodetic Survey; in grounds of Dudley Observatory, station of 1858. Coast and Geod. Survey Report, 1881, Appendix 9.

17.—SALEM,* MASS.

$\phi=42^\circ 31'.9$ $\lambda=70^\circ 52'.5$ W. of Gr.

(Fort Lee.)

		° ′	
1	1750..	7 43 W.	A rough auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6. [$w=\frac{1}{2}$.—Sch.]
2	1781, August.	7 02	President Willard, at Beverly, in $\phi=42^\circ 33'$, $\lambda=70^\circ 54'$ W. Mean of seven observations. Sill. Jour., vol. xvi., 1829. [Reduction to Salem $-8'$.—Sch.]
3	1805, November.	5 57	Dr. Bowditch, in Summer st., Salem; from 115 observations.
4	1808, June.	5 20	Dr. Bowditch, one-eighth of a mile south of above place; from 112 observations. [$w=\frac{1}{4}$.—Sch.]
5	1810, April.	5 47.7 5 13.4	Dr. Bowditch, about one-fourth of a mile east of the place of 1805. [Mean $5^\circ 30'.6$—Sch.]
	1810, April, to 1811, May.	6 22.6	Dr. Bowditch, result of a third needle from 5125 observations from monthly means. [Mean of two values, $5^\circ 56'.6$ for 1810.8—Sch.]
6	1833..	8 30	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., 1833. [$w=\frac{1}{2}$—Sch.]
7	1849, August 20.	10 14.5	Prof. G. W. Keely, observer for U. S. Coast Survey; at Fort Lee. Coast Survey Report for 1854, p. 143.
8	1855, August 25.	10 49.7	C. A. Schott. asst. Coast Survey; at Fort Lee. Coast Survey Report for 1855, p. 337.
9	1877.5	11 30	I. K. Harris, communicated to Superintendent in a letter dated Lynn, Feb. 18, 1878.
10	1887, October 22, 23.	12 38.1 W.	J. B. Baylor, asst. C. and Geod. Survey. Position as in 1855. MS. in archives.

*The locality is subject to local magnetic deflections; these disturbances have been traced to and over Cape Ann.

Collection of Magnetic Declinations, etc.—Continued.

18.—OXFORD, CHENANGO COUNTY, N. Y.

$\phi = 42^\circ\ 26'.5 \qquad \lambda = 75^\circ\ 40'.5$ W. of Gr.

		° ′	
1	1792–1795.	3 W.	E. B. McCall, surveyor; in a letter to the Superintendent of the Coast Survey, dated Dec. 22, 1858.
2	1817..	3	E. B. McCall; in $\phi = 42^\circ\ 26'.5$, $\lambda = 75^\circ\ 42'$ W. Reference as above. [Weight ½ given to this value.—SCH.]
3	1828, July 7.	4 30	
4	1834, October 9.	3 52	Regents' Report; in $\varphi = 42^\circ\ 28$, $\lambda = 75^\circ\ 33'$ W.; also Prof. E. Loomis's collection, Sill. Jour., vol. xxxiv, 1838.
5	1836, October 5.	4 09	
6	1837..	4 30	Regents' Report of 1839; also Sill. Jour., 1838.
7	1838, July 6.	4 30	At Guilford; in $\phi = 42^\circ\ 24'$, $\lambda = 75^\circ\ 26'$ W. Regents' Report for 1839; also Sill. Jour., 1838. [4° 27′ when reduced to Oxford.—SCH.]
8	1849, November 27.	5 11	E. B. McCall; letter to Supt. of Dec. 22, 1858.
9	1857, April 4.	5 44	
10	1858, February 4.	5 47	
11	1858, December.	5 50	
12	1873, December 1.	6 52	Erving Taintor, local surveyor.
13	1874, May 29, 30; June 2, 3, 4, 5, 6.	6 55.7	Dr. T. C. Hilgard, observer for U. S. Coast Survey; on hill about three-fourths of a mile north of railroad depot; in $\phi = 42^\circ\ 26'.5$, $\lambda = 75^\circ\ 40'.5$ W. Coast and Geodetic Survey Report for 1881, Appendix 9.
14	1885, September 23, 24, 25.	7 43.3 W.	J. B. Baylor, subasst. Coast and Geodetic Survey; near Taylor and Scott streets, in $\phi = 42^\circ\ 26'.5$, $\lambda = 75^\circ\ 40'.5$ W. MS. in archives of the Survey.

19.—CAMBRIDGE, MASS.

$\phi = 42^\circ\ 22'.9 \qquad \lambda = 71^\circ\ 07'.7$ W. of Gr.

(Harvard College Observatory.)

		° ′	
1	1708..	9 W.	Brattle, observer; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838; also Mem. Am. Acad., vol. ii, new series, Cambridge, 1846.
2	1742..	8	Prof. J. Winthrop's table; Sill. Jour., vol. xvi, 1829; also Mem. Am. Acad., vol. ii, new series, Cambridge, 1846. [See remarks on the Winthrop table in connection with the Boston series.—SCH.]
	1750..	7.8	A rough auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6. [Not used.—SCH.]
3	1757..	7 20	Prof. J. Winthrop; reference as above.
4	1761..	7 14	Dr. Williams; Mem. Am. Acad., vol. ii, new series, Cam., 1846.
5	1763..	7 00	Prof. J. Winthrop; Sill. Jour., vol. xvi, 1829.
6	1780..	7 02	Dr. Williams; Encyclopædia Metropolitana, London, 1848.
7	1782..	6 45	Dr. Williams; reference as above; also Mem. Am. Acad., 1846, where declination 6° 46′ W. is given. Prof. Sewall, mean of extremes 6° 21′ and 7° 08′ W.; Sill. Jour. for 1829. See also first vol. of Mem. Am. Acad. [Used 6°.75 W.—SCH.]
	1782..	6 44	
8	1783..	6 52	Dr. Williams; Mem. Am. Acad., 1846; also Encycl. Metrop., 1848.
9	1788..	6 38	Dr. Williams; Mem. Am. Acad., 1846.
10	1810..	7 30 W.	Prof. Farrar; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838.

Collection of Magnetic Declinations, etc.—Continued.

CAMBRIDGE, MASS.—Continued.

		° ′	
	1833..	8 0 W.	Peter Barlow's isogonic chart in Phil. Trans. Roy. Soc., 1833. [Not used.—SCH.]
11	1835..	8 51	Prof. Farrar; Prof. E. Loomis's collection, Sill. Jour., vol. xxxiv, 1838.
12	1837..	9 09	Mem. Am. Acad., Cambridge, 1846.
13	1840.4	9 18	W. C. Bond, director Harvard College Observatory; Mem. Am. Acad., 1846. In $\phi=42° 22'.9$, $\lambda=71° 07'.7$ W.
14	1842.2	9 34.9	Prof. Jos. Lovering; *half-hourly observations during one year, Oct., 1841, to* Oct., 1842; Mem. Am. Acad., vol. iv, 1850.
15	1844..	9 39	W. C. Bond, director Harvard College Observatory; MS. communicated by Prof. J. Lovering, of Harvard College.
16	1845, June 2.	9 32	Dr. John Locke, Smithsonian Contributions to Knowledge, vol. iii, 1852.
17	1850, August 9.	9 30	Lieut. J. C. Ives; at Harvard College Observatory; Coast Survey Report for 1856, p. 222.
18	1852..	10 08	W. C. Bond, director Harvard College Observatory; communicated by Prof. J. Lovering in letter of May 29, 1855.
19 {	1854..	10 39	Observer and reference as before.
	1854, May 10.	9 46	Lieut. J. C. Ives, at Har. Coll. Obs'y; Coast Survey Rep. for 1856, p. 222. [The mean $+10°.21$ is used.—SCH.]
20	1855, May 22, 23.	10 54.6	W. C. Bond, director Har. Coll. Obs'y; communicated by him in letter of Dec. 24, 1858.
21 {	1856, May 16.	10 50.3	W. C. Bond; reference as above.
	1856, July 17.	10 06	Karl Friesach; at Cambridge Obs'y; results corrected for diurnal variation; Berichte der Kais. Kön. Akademie der Wiss., Vienna, vol. 29, 1858. [The mean $+10°.47$ is used.—SCH.]
22	1859, March.	10 48	Lieut. W. P. Smith, U. S. E.; at Har. Coll. Obs'y; communicated by Capt. G. G. Meade, U. S. E.
23	1866–'67–'68.	10 41	Prof. Jos. Winlock, director Harvard College Observatory; from a large number of observations communicated by him in Nov., 1872. [Computed by me and reduced to mean epoch 1867.5—SCH.]
24	1879, August 7, 9.	11 46.3 W.	J. B. Baylor, U. S. Coast and Geodetic Survey; in the grounds of the Har. Coll. Obs'y, $\phi=42° 22'.8$, $\lambda=71° 07'.6$ W.

20.—BOSTON, MASS.

$\phi=42° 21'.5$ $\lambda=71° 03'.9$ W. of Gr.

(State-house.)

		° ′	
	1700..	10 W.	Prof. J. Winthrop's table, Sill. Jour., vol. xvi, 1829; also Mem. Am. Acad., vol. ii, new series, Cambridge, 1846. [Prof. E. Loomis has pointed out the observed and interpolated values of the Winthrop table; only the former are used. The table was originally published in the "Boston Post Boy," July 2, 1764, for which information I am indebted to Mr. J. H. Trumbull—SCH.]

Collection of Magnetic Declinations, etc.—Continued.

BOSTON, MASS.—Continued.

		° ′	
1	1700..	10 W.	Edm. Halley's isogonic chart for epoch 1700; reproduced by photolithography in Greenwich astron'l obser's for 1869. [Winthrop's value is supposed to be taken from Halley.]
2	1708..	9	Mathews, observer; Sill. Jour. for 1829, Dr. N. Bowditch. See also Encyclopædia Metropolitana, London, 1848.
3	1741..	7 30	Mathews; Encyclo. Metrop., London, 1848.
	1750..	7.8	A rough auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6. [Not used.—SCH.]
4	1775–'76.	7 40	Des Barres's Atlantic Neptune, London, 1781.
5	1782..	7 00	Dr. N. Bowditch; Sill. Jour. for 1829; also first volume of Mem. Am. Acad.
6	1793..	6 30	Mem. Am. Acad., new series, Cambridge, 1846; mean of 1644 observations.
7	1807..	6 05	Communicated by W. Rotch; letter dated Fall River, Feb. 17, 1874.
8	1833..	8 00	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc. for that year.
9	1839..	9 06	W. C. Bond; at Dorchester, in $\phi = 42° 19'$, $\lambda = 71° 04'$ W.; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1840.
10	1846, September 6–8.	9 31.4	Lieut. T. J. Lee, asst. Coast Survey; at Dorchester Heights, South Boston, in $\phi = 42° 20'.0$, $\lambda = 71° 02'.5$; Coast Survey Report for 1854, p. 143.
11	1855, August 24.	10 13.7	C. A. Schott, asst. Coast Survey, in South Boston; locality as above; Coast Survey Report for 1855, p. 337.
12	1872, September 28, 30; October 1.	11 15.2	A. H. Scott, observer for U. S. Coast Survey; locality as above; Coast and Geodetic Survey Report for 1881, App. 9.
13	1877.5	11 36	At meridian line on Boston Common, from records at the City Hall, communicated by I. K. Harris, Feb. 18, 1878.
	1884, October 18.	11 31 W.	Lieut. C. C. Cornwell, U. S. S. Powhatan; at sea, in $\phi = 42° 20'$, $\lambda = 70° 47'$ W.; Naval Prof. Papers No. 19, Washington, 1886. [Reduction to Boston harbor uncertain; not used.—SCH.]

21.—PROVINCETOWN, CAPE COD, MASS.

$\phi = 42° 03'.1$ $\lambda = 70° 11'.3$ W. of Gr.

(Town Hall.)

		° ′	
	1609, July 28.	6 0 W.	Hudson, third voyage; off the Isles of Shoals } Prof. E. Loomis, in Sill.
	1609, July 29.	5 30	Hudson; near Cape Cod, at sunset. } Jour., vol. xxxix, 1840. [These values appear too small, considering that Champlain found 18° 40′ W. at Malle Barres, now Nauset Inlet, Cape Cod, between 1608 and 1612; but Champlain's value errs probably in the opposite direction. Hudson found zero declination, Aug. 2, off Cape Cod. Not used.—SCH.]
1	1630, about.	12.2	On a map from R. Dudley's Arcano del Mare, published at Florence in 1646, we have the magnetic declination 12° W. for latitude 42° 30′, longitude 69° W. [This value refers to a time later than that of Hudson and Champlain, but it must be earlier than 1639, the year of Dudley's death; see Narrative and Crit. Hist. of Am., by Justin Winsor, vol. iii, 1884, p. 303. 12°.2 W., with $w = \frac{1}{4}$, is here adopted.—SCH.] The probable error of this value may be estimated as between 2 and 3°.
2	1700..	9 30	Edm. Halley's Tabula Nautica; Variationum, etc. Greenwich Astro'l Observations for 1869. [$w = \frac{1}{2}$.—SCH.]
		9.6 W.	A rough auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6. [Not used.—SCH.]

Collection of Magnetic Declinations, etc.—Continued.

PROVINCETOWN, CAPE COD, MASS.—Continued.

		° ′	
3	1750..	7.7 W.	A rough auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6. [$w=\frac{1}{2}$.—SCH.]
4	1776..	6 30	At Nantucket, from a chart. Prof. Loomis, in Sill. Jour., vol. xxxix, 1840. [The reduction to Cape Cod may be estimated at +45′, hence referred value 7° 15′ W.—SCH.]
5	1833..	8 15	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., for 1833. [$w=\frac{1}{2}$—SCH.]
6	1835, September.	9 20	Major J. D. Graham, U. S. Eng. at House Pt. Island, in $\phi=42°\ 03'$, $\lambda=70°\ 04'$ W. Government survey of Cape Cod. Sill. Jour., vol. xxxix, 1840; also Phil. Trans. Roy. Soc., 1849.
7	1860, September 14, 15.	11 23.5 W.	C. A. Schott, asst. Coast Survey; near Town Hall, in $\phi=42°\ 03'.2$, $\lambda=70°\ 11'.1$ W. Coast and Geodetic Survey Report for 1881, App. 9.

22—PROVIDENCE, R. I.

$\phi=41°\ 50'.2$ $\lambda=71°\ 23'.8$ W. of Gr.

(Brown University.)

		° ′	
1	1717..	9 36 W.	R. Jackson, on a map of Providence.
	1720..	9 28	Sill. Jour., vol. xliv, 1843. [The declinations between 1717 and 1843, incl. as given by M. B. Lockwood, civil engineer, are not stated to be from actual observations or from recorded bearings, and I strongly suspect that the table of results here presented is like the Winthrop table, and that for Hatboro', Pa., made up in great part by interpolation. Values 1720 to 1765, incl., not used.—SCH.]
	1725..	9 14	
	1730..	8 54	
	1735..	8 39	
	1740..	8 15	
	1745..	7 59	
	1750..	7 40	
	1755..	7 21	
	1760..	6 57	
	1765..	6 43	
2	1769..	6 30	Dr. B. West. Prof. E. Loomis, in Sill. Jour., vol. xxxiv, 1838.
	1775..	6 20	[See remark above; values 1775 to 1810, incl., not used.—SCH.]
	1780..	6 16	
	1785..	6 13	
	1790..	6 10	
	1795..	6 10	
	1800..	6 15	
	1805..	6 19	
	1810..	6 24	
3	1815..	6 30	M. Brown, B. Lockwood, and G. Shelden.
4	1819..	6 37	[Probably observed by Lockwood.—SCH.]
	1825..	6 51	[See remark above; values not used.—SCH.]
	1830..	7 10	
	1833..	6 00	Peter Barlow's isogonic chart; Phil. Trans. Roy. Soc., 1833. [Not used.—SCH.]
5	1835..	7 34	
6	1840..	8 25	
7	1841..	8 31	
8	1842..	8 39	
9	1843..	8 46 W.	

Collection of Magnetic Declinations, etc.—Continued.

PROVIDENCE, R. I.—Continued.

		° ′	
10	1855, August 20.	9 31.5 W.	C. A. Schott, assist. Coast Survey, east of Brown University, in $\phi=41°$ $50'.2$, $\lambda=71° 23'.7$; U. S. Coast Survey Report for 1881, App. 9.
11	1884, June 20.	11 07.7	O. T. Sherman; Report Board of Managers Yale College Obs'y, 1884–'85; in $\phi=41° 50'$, $\lambda=71° 24'$ W.
12	1885, April 11, 13, 14.	11 09.6 W.	J. B. Baylor, U. S. Coast and Geodetic Survey; station east of Brown University, near that of 1855, in $\phi=41° 50'.2$, $\lambda=71° 23'.7$ W. MS. in archives.

23.—HARTFORD, CONN.

$\phi=41° 45'.9$ $\lambda=72° 40'.4$ W. of Gr.

(State-house.)

		° ′	
1	1750..	6.78 W.	A rough auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No 6. [$w.=\frac{1}{2}$.—SCH.]
2	1786..	5 25	Dr. Williams; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838.
3	1810..	4 46	Asher Miller, at East Hartford, in $\phi=41° 46'$, $\lambda=72° 38'$ W.; reference as above.
4	1824..	5 45	N. Goodwin; reference as before.
5	1828..	6 03	N. Goodwin; reference as before.
5	1829..	6 03	N. Goodwin; reference as before.
6	1859, July 7, 27.	7 17.0	C. A. Schott, asst. Coast Survey, in City Park; Coast Survey Report for 1859, p. 296.
7	1867, August 15, 17.	7 49.3	C. A. Schott, asst. Coast Survey, near the Athenæum, in $\phi=41° 45'.9$, $\lambda=72° 40'.4$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
	1875 (?).	8 58	T. C. Ellis, civil engineer. Report Chief of Engineers, U. S. A. In $\phi=41°$ $45'$, $\lambda=72° 40'$ W. [Not used.—SCH.]
8	1879, July 24, 25, 26.	8 34.0 W	J. B. Baylor, U. S. Coast and Geodetic Survey; station of 1859 in City Park, in $\phi=41° 45'.9$, $\lambda=72° 40'.5$ W.; Coast and Geodetic Survey Report for 1881, App. 9.

24.—NEW HAVEN, CONN.

$\phi=41° 18'.5$ $\lambda=72° 55'.7$ W. of Gr.

(Yale College.)

		° ′	
1	1750..	6.24 W.	A rough auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6. [$w.=\frac{1}{2}$.—SCH.]
2	1761..	5 47	President Stiles.... Prof. E. Loomis's collection, Sill. Jour., vol. xxxiv, 1838.
3	1775..	5 25	Prof. Strong ...... Prof. E. Loomis's collection, Sill. Jour., vol. xxxiv, 1838.
4	1780..	5 15	President Stiles.... Prof. E. Loomis's collection, Sill. Jour., vol. xxxiv, 1838.
5	1811..	5 10	Nathan Redfield... Prof. E. Loomis's collection, Sill. Jour., vol. xxxiv, 1838.
	1818, August.	5 45	Hon. De Witt, Sill. Jour., vol. xvi, 1829. [Not used.—SCH.]
	1819..	4 35	Prof. Fisher, of Yale College; Prof. E. Loomis's collection, Sill. Jour., vol. xxxiv, 1838. [Not used.—SCH.]
6	1819, May. 1820, April.	4 25.4 W.	Prof. Fisher, from hourly observations; Sill. Jour., vol. xvi, 1829.

Collection of Magnetic Declinations, etc.—Continued.

NEW HAVEN—Continued.

		° ′	
7	1828	5 17 W.	N. Goodwin; Prof. E. Loomis's collection, Sill. Jour., vol. xxxiv, 1838.
8	1834, November. 1835, November.	5 40.6	Prof. E. Loomis, from hourly observations; Sill. Jour., vol. xxx, 1836.
	1835	5 52	Prof. E. Loomis's collection of 1838. [Not used.—SCH.]
9	1836	5 55	E. C. Herrick; Prof. E. Loomis's collection of 1838.
10	1837, November.	5 50	E. C. Herrick; Sill. Jour., vol. xxxiv, 1838.
11	1840	6 10	E. C. Herrick; Prof. E. Loomis's collection, Sill. Jour., vol. xxxix, 1840.
12	1844, August 28.	5 45.1	Prof. J. Renwick, observer for U. S. Coast Survey at Yale College, in $\phi=41° 18'.5$, $\lambda=72° 55'.7$; Coast and Geod. Survey Report for 1881, App. 9.
13	1845, September 10.	6 17.3	Prof. J. Renwick, observer for U. S. Coast Survey at Pavilion Hotel, south of college, near the bay, in $\phi=41° 18'$, $\lambda=72° 54'.6$ W. Reference as above.
	1847, September 25, 28; October 1, 2.	7 27.2	R. H. Fauntleroy, asst. Coast Survey, at Fort Wooster, in $\phi=41° 16'.9$, $\lambda=72° 53'.6$ W. Reference as above. [Local deflection; observation not used.—SCH.]
	1848, August 21–29.	7 25.5	J. S. Ruth, subasst. Coast Survey, at Fort Wooster, position and reference as before. [Not used.—SCH.]
14	1848, August 10, 12, 14.	6 37.9	J. S. Ruth, subasst. Coast Survey, Pavilion Hotel, position as in 1845. Reference as before.
	1848, August 30, September 1.	6 31.9	J. S. Ruth, subasst. Coast Survey, at Oyster Point, in $\phi=41° 17'.0$, $\lambda=72° 55'.7$ W., in meridian of Yale College. Coast and Geod. Survey Report for 1881, App. 9. [Used mean, +6°.58—SCH.]
15	1855, August 17.	7 02.7	C. A. Schott, asst. Coast Survey at Oyster Point, near position of 1848, in $\phi=41° 16'.9$, $\lambda=72° 55'.8$ W. Reference as above.
	1871, March.	7 22	G. H. Mann, C. E., on College Green, survey of the harbor of New Haven by the U. S. Engineers; MS. communication. [Not used; local deflection suspected.—SCH.]
16	1872	8 27.5	R. M. Bache, asst. Coast Survey; topographic and hydrographic survey of New Haven Harbor and vicinity; from bearings of trigonometrical lines. Hydrographic chart No. 1170.
17	1878, July 18.	8 41.2	Dr. T. E. Thorpe, in Prof. Silliman's garden, in $\phi=41° 18'.7$, $\lambda=72° 55'.6$ W. Proceedings of Royal Society, No. 200, 1880.
18	1884, January to May.	8 50.9	O. T. Sherman, Yale College Observatory grounds, near Silliman's garden, in $\phi=41° 18'.7$, $\lambda=72° 55'.6$. Report to Board of Managers Yale College Obs'y 1884–85. [Mean, +8°.93—SCH.]
	1884, June to December.	9 01.0	
	1884, July 22.	8 46.2	O. T. Sherman, at South End, in $\phi=41° 14'.2$, $\lambda=72° 53'$ W. Reference as above. [Not used.—SCH.]
19	1885, January to June.	9 00.3 W.	O. T. Sherman, Yale College Observatory grounds. Reference as above.

Collection of Magnetic Declinations, etc.—Continued.

25.—NANTUCKET, MASS.

$\phi = 41° 17'.0$ $\lambda = 70° 06'.0$ W. of Gr.

(Mitchell's observatory.)

		° ′	
1	1700..	{ 8 15 W.	Edm. Halley's Tabula Nautica, etc. Greenwich Astro'l Observations for 1869.
		8.6	A rough auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6. [Mean 8°.42 W. and $w = \frac{1}{2}$.—SCH.]
2	1750..	6.9	A rough auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6. [$w = \frac{1}{2}$.—SCH.]
3	1775..	6 30	J. F. Des Barres's Atlantic Neptune, London, 1781.
	1776..	6 30	From a chart; Prof. E. Loomis's collection, in Sill. Jour., vol. xxxiv, 1838. [Probably of the same origin as preceding value. Not used.—SCH.]
4	1833..	7 30	Peter Barlow's isogonic chart of 1833; Phil. Trans. Roy. Soc., of that year. [$w = \frac{1}{2}$.—SCH.]
5	1834..	8 27	Wm. Mitchell; Sill. Jour., vol. xlvi.
6	1838–'39.	9 02.3	
7	1842, August & September.	9 09	
8	1843, September.	9 10	
9	1846, July 30, 31.	9 14.0	Lieut. T. J. Lee, U. S. E., assist. Coast Survey; near Mitchell's house; Coast Survey Report for 1854, p. 143.
10	1855, August 22.	9 58.3	C. A. Schott, assist. Coast Survey; near Nantucket Harbor light, on beach, in $\phi = 41° 17'.5$, $\lambda = 70° 06'.0$ W. Coast Survey Report for 1855, p. 337.
11	1867, May 28, 29, 30.	10 19.9	C. O. Boutelle, assist. Coast Survey; at Nantucket Cliff, in $\phi = 41° 17'.2$, $\lambda = 70° 06'.3$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
12	1879, July 31, August 2.	11 27.9	J. B. Baylor, U. S. Coast and Geodetic Survey; at the Cliff station; reference as above.
13	1883, June 10.	11 38 W.	Lieut. E. S. Prime, U. S. S. Yantic; at sea, in $\phi = 41° 29'$, $\lambda = 70° 12'$ W. Naval Professional Papers No. 19. Washington, 1886. [Reduction to Nantucket about −12′, hence Dec. = + 11°.43—SCH.]

26.—COLD SPRING HARBOR, LONG ISLAND, N. Y.

$\phi = 40° 52'$ $\lambda = 73° 28'$ W. of Gr.

		° ′	
1	1750..	5.7 W.	A rough auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6. [$w = \frac{1}{2}$.—SCH.]
2	1771, June 13.	5 07	H. Lefferd; communicated Oct. 15, 1886, by Edmund Jones, surveyor.
3	1818, May.	4 52	E. Hicks; authority as before.
4	1844, September 15.	6 11.6	J. Renwick, observer, C. and Geod. Survey Report for 1881, App. No. 9; at Lloyd's Harbor, in $\phi = 40° 55'.6$, $\lambda = 73° 25'.1$.
	1844, September 16.	6 50.5	J. Renwick, observer. Reference as before. At Oyster Bay, in $\phi = 40° 52'.3$, $\lambda = 73° 31'.6$. [Mean 6° 31′ W.—SCH.]
5	1864, December 28.	7 47	S. V. Whiting; communicated by Edm. Jones, Oct. 15, 1886.
6	1886, July 7.	8 34 W.	J. and E. Jones; reference as above.*

* Nos. 2, 3, 5, and 6 are derived from bearings of old lines and rest on the assumption of the present difference of declination between New York and Cold Spring Harbors, viz, 35′.

Collection of Magnetic Declinations, etc.—Continued.

27.—NEW YORK CITY AND VICINITY, N.Y.

$\phi=40^\circ\ 42'.7$ $\lambda=74^\circ\ 00'.4$ W. of Gr.

(New York City Hall.)

		° ′		
1	1609, September 1.	2	W.	Hudson, on his third voyage, Sept. 8, found 8° W. on the Jersey shore, a little below the mouth of the Hudson River. The day before he found not above 2° W. A few miles up the Hudson he found, in 1609, Sept. 13, 13° W. Prof. E. Loomis's collection in Sill. Jour., vol. xxxix, 1840; extract furnished by Prof. J. Sparks from 3d vol. of Purchas' Pilgrims. [The known local deflections about the Palisades render the last result of doubtful value, and the first does not appear to possess much probability; the best that may now be done is perhaps to adopt provisionally the value $8^\circ\pm2^\circ$.—SCH.]
	1609, September 2.	8		
	1609, September 13.	13		
2	1630, about.	11.5		An auxiliary value derived from R. Dudley's Arcano del Mare, Florence, 1646–'47; see Appendix No. 6, Report of 1888. [$w=\frac{1}{2}$.—SCH.]
3	1684..	8 45		Philip Welles, surveyor-general. Report of the New York Commissioners on the Connecticut boundary, made to the New York legislature in April, 1857 (Sen. Doc. 165, p. 155). Information received from J. H. Trumbull, April, 1876.
4	1686..	9 00		Geo. Keith, at Sandy Hook; line run between E. and W. New Jersey; records of proprietors of New Jersey. Communicated by Prof. G. H. Cook, State geologist of N. J., Oct. 11, 1879.
5	1691..	8 45		On Staten Island; Geological Survey of New York, 1858. E. Duxbury's patent.
6	1700.0	8 20		Edm. Halley's isogonic chart for epoch 1700, reproduced by photolithography in the Greenwich observations for 1869.
		8.1		A rough approximate value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6. [Not used.—SCH.]
7	1714..	8 45		John Beatty, deputy surveyor; on map of Livingston's manor, New York. Engraved in O'Callaghan's Doc. Hist. N. Y., vol. iii, 414. Received from J. H. Trumbull.
8	1723..	7 20		G. Burnet; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838.
	1724..	7 20		Cadwalader Colden, one of the commissioners of the New York and Connecticut boundary in 1724. Report of commissioners of 1857. Received from J. H. Trumbull. [The two results are supposed to refer to the same source.—SCH.]
9	1750..	6 22		Alexander; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838.
		5 28		An auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6. [Mean, 5°.92 W.—SCH.]
10	1755..	5 00		Evans; reference as above.
	1775.0	7		J. F. W. Des Barres's Atlantic Neptune, London, 1781; at Sandy Hook. [Not used.—SCH.]
11	1789..	4 20		Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838; also Encyclo. Metrop., 1848.
12	1824..	4 40		Blunt's map; Prof. E. Loomis's collection of 1838.
	1833..	3		Peter Barlow's isogonic chart. Phil. Trans. Roy. Soc., 1833. [Not used.—SCH.]
13	1834..	4 50		Capt. Owen; Prof. E. Loomis's collection of 1838.
14	1837..	5 40	W.	Prof. J. Renwick, at Columbia College (near City Hall). Prof. E. Loomis's collection of 1838.

Collection of Magnetic Declinations, etc.—Continued.

NEW YORK AND VICINITY, N. Y.—Continued.

		° ′	
15	1840, June 16 to July 11.	5 01 W.	Lieut. S. C. Rowan, U. S. N., observer for U. S. Coast Survey; at Howard, Staten Island, in $\phi=40° 37'.6$, $\lambda=74° 05'.4$; Coast and Geodetic Survey Report for 1881, App. 9.
	1840, July 18 to October 16.	5 53	Lieut. S. C. Rowan, U. S. N., observer for U. S. Coast Survey; at Bergen Neck, in $\phi=40° 45'.8$, $\lambda=74° 02'.6$ W. Reference as before. [Mean, $+5°.45$ for 1840.6—SCH.]
16	1841 ..	6 06	Douglass's map of New Jersey; Coast Survey archives.
17	1842, September.	5 32.5	Coast Survey observer at Sandy Hook, N. J., in $\phi=40° 27'.7$, $\lambda=74° 00'.2$ W.; Coast and Geod'c Survey Report for 1881, App. 9. [Probable reduction to New York $+22'$—SCH.]
	1844, January.	5 51.1	Lieuts. G. M. Bache and J. Hall, U. S. N., observers for U. S. Coast Survey; at Sandy Hook; reference, position, and reduction as before. [Not used—SCH.]
	1844, August 20, 22.	5 51.0	Prof. J. Renwick, observer for U. S. Coast Survey; at Sandy Hook, N. J.; reference, position, and reduction as before. [Not used.—SCH.]
18	1844, August 24.	6 13.1	Prof. J. Renwick, observer for U. S. Coast Survey; at Columbia College (old position), in $\phi=40° 42'.6$, $\lambda=74° 00'.5$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
19	1845, September 4.	6 25.3	Prof. J. Renwick, observer for U. S. Coast Survey; reference and position as before.
20	1846, April 30.	5 09.7	Dr. John Locke, observer for U. S. Coast Survey; at Bloomingdale Asylum, Manhattanville, in $\phi=40° 50'.3$, $\lambda=73° 56'.7$ W.; Coast and Geod'c Survey Report for 1881, App. 9.
	1846. May 4.	4 57.4	Dr. John Locke, observer for U. S. Coast Survey; at Mt. Prospect (formerly Flatbush), Brooklyn, in $\phi=40° 40'.3$, $\lambda=73° 58'.0$. Reference as before. Other observations at this place are given in the Regents' Report of the University of the State of New York, viz: ° ′ / ° ′ Oct. 1834, 4 25 W. / Dec. 22, 1840, 5 00 W. Oct. 1835, 4 45 / Dec. 30, 1841, 5 12 Oct. 1837, 4 45 / Dec. 30, 1842, 5 10 Dec. 18, 1838, 4 45 / Dec. 20, 1847, 5 30 Jan. 4, 1840, 4 55 / Oct. 26, 1848, 5 15 Assigned position $\phi=40° 37'$, $\lambda=73° 58'$ W.
	1846, May 7.	5 37.4	Dr. John Locke, observer for U. S. Coast Survey; at Cole, Staten Island, in $\phi=40° 31'.9$, $\lambda=74° 14'.1$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
	1846, May 14.	5 35.1	Dr. John Locke, observer for U. S. Coast Survey; at Newark, in $\phi=40° 44'.8$, $\lambda=74° 10'.0$ W.; Coast and Geodetic Report for 1881, App. 9. [Mean value, $+5°.57$ for 1846.3—SCH.]
21	1847, October 16–20.	5 41.0	R. H. Fauntleroy, assistant Coast Survey; at Legget, $\phi=40° 48'.9$, $\lambda=73° 53'.5$ W. Reference as above.
22	1855, August 7.	6 39.6	C. A. Schott, assist. Coast Survey; at Governor's Island, in $\phi=40° 41'.5$, $\lambda=74° 01'.1$ W.; Coast and Geod'c Survey Report for 1881, App. 9.
	1855, August 8.	7 02.1	Observer and reference as above; at Bedloe's (Liberty) Island, in $\phi=40° 41'.4$, $\lambda=74° 02'.7$.
	1855, August 11.	6 28.0 W.	Observer and reference as before; at receiving reservoir (now in Central Park), in $\phi=40° 46'.7$, $\lambda=73° 58'.2$ W. [Mean used, $+6° 43'.2$—SCH.]

Collection of Magnetic Declinations, etc.—**Continued.**

NEW YORK AND VICINITY, N. Y.—Continued.

		° ′	
	1855, August 14.	6 11.2 W.	Observer and reference as before; at Sandy Hook, N. J. Position as in 1842 and 1844. [Not used.—SCH.].
23	1860, September 21, 22.	6 44	C. A. Schott, asst. Coast Survey; at Mt. Prospect (now Brooklyn new water works), in $\phi=40° 40'.3$, $\lambda=70° 58'.0$ W.; Coast and Geod'c Survey Report for 1881, App. 9.
	1872, October 31, November 1 and 2.	8 45.8	A. H. Scott, U. S. Coast Survey; at Central Park, west of mall, in $\phi=40° 46'.2$, $\lambda=73° 58'.2$ W.; reference as above. [Not used; local deflection.—SCH.]
24	1873, November 5, 6, 7, 9.	7 09.0	Dr. T. C. Hilgard, observer for U. S. Coast Survey; at Sandy Hook, N. J. Station near that of 1842, '44, '55, $\phi=40° 27'.7$, $\lambda=74° 00'.2$ W. [Reduction to New York + 20′—SCH.]
25	1874, August.	7 23	Report of Chief of Engineers, U. S. A., for 1875; Chart of Way Reef, Hell Gate.
26	1879, July 17, 18.	7 32.0	J. B. Baylor, U. S. Coast and Geod'c Survey; at Sandy Hook, N. J.; station of 1873. [Reduction to New York + 20′.—SCH.]
	1883, August 24.	7 16	Lieut. R. B. Beck, U. S. S. Swatara. in $\phi=40° 29'$, $\lambda=73° 51'$ W.
	1884, May 1.	7 00	Lieut. U. Sebree, G. R. S. Thetis, in $\phi=40° 26'$, $\lambda=73° 51'$ W. Naval Professional Papers. No. 19, Washington, 1886.
	1884, July 17.	7 34	Lieut. R. B. Beck, U. S. S. Swatara, in $\phi=40° 30'$, $\lambda=73° 50'$ W.
			[Reduction to Sandy Hook, for values of 1883 and 1884, about −9′; not used.—SCH.]
27	1885, September 30, October 1, 4.	7 52.8	J. B. Baylor, subasst. Coast and Geod'c Survey; at Sandy Hook, N. J., station of 1879. MS. in Coast and Geod'c Survey archives. [Reduction to New York about + 20′.—SCH.]
	1885, October 16, 17, 18.	8 59.7 W.	J. B. Baylor, subasst. Coast and Geod'c Survey; in Riverside Park, N. Y., in $\phi=40° 49'$, $\lambda=73° 57'.6$ W. MS. in archives of the Survey. [Not used on account of local deflection.—SCH.]

TYRONE, BLAIR COUNTY, PA.

$\phi=40° 40'$ $\lambda=78° 15'.5$ W. of Gr.

		° ′	
1	1871, September 25.	3 06 W.	Observer W. G. Waring; results communicated by him to the office by letter, dated Tyrone, Pa., April 14, 1879. [Correcting the values for diurnal variation and contracting to yearly means, we have the following results for discussion:
	1871, September 27.	3 12	1871.65 : +3.15°
2	1873, April 3.	3 24	1873.36 : 3.35
	1873, May 10; noon.	3 22	1874.41 : 3.33
	1873, June 18; 10 a. m.	3 19	1875.42 : 3.43
3	1874, May 29.	3 20	1878.88 : 3.70
4	1875, June 2.	3 26	1879.21 : 3.80
5	1878, November 6; 10½ a. m.	3 45	
	1878, November 14; 9 a. m.	3 39	
	1878, November 14; noon.	3 43	
	1878, December 13; 4 p. m.	3 43.5	[The only deduction that can be made at present is for value of annual increase between 1871 and 1880, viz: +3′.3—SCH.]
6	1879, March 18; 1 p. m.	3 52 W.	

Collection of Magnetic Declinations, etc.—Continued.

28.—BETHLEHEM, NORTHAMPTON COUNTY, PA.

$\phi=40° 36'.4$ $\lambda=75° 22'.9$ W. of Gr.

(Sayre Observatory, Lehigh University, South Bethlehem.)

		° ′	
1	1757--	6 30 W.	R. W. Walker,* from bearings of old lines. [The weight one-half is given to this value.—SCH.]
2	1784--	2 53	Reference as above.*
3	1799--	1 52	Reference as above.* [The weight one-half is given to this value.—SCH.]
4	1841, July 23.	3 26	Prof. A. D. Bache, at Easton, 3° 38′.0 W., in $\phi=40° 42'$, $\lambda=75° 15'$ W.; Coast Survey Report for 1862, App. 19. [Reduction to Bethlehem, by isogonic map in Coast Survey Report for 1862, —12′.—SCH.]
5	1851--	3 50	R. W. Walker,* from bearings of old lines.
6	1874, June 20.	5 19.5	Dr. T. C. Hilgard, near Lehigh University; in $\phi=40° 37'.0$, $\lambda=75° 22'.9$ W.; Coast and Geodetic Survey Report for 1881, App. 9. [Position corrected.—SCH.]
7	1878.2	5 37	R. W. Walker,* from bearings of old lines.
8	1881.2	5 52	Prof. C. L. Doolittle, Lehigh University.*
9	1882.7	6 05	R. W. Walker,* deduced from 80 observations made by students.
10	1884.0	6 06 W.	R. W. Walker.*

* This result was given by Mr. R. W. Walker, and communicated to me by Prof. M. Merriman, of Lehigh University, letter of June 7, 1884.—SCH.

29.—HUNTINGDON, HUNTINGDON COUNTY, PA.

$\phi=40° 31'$ $\lambda=78° 02'$ W. of Gr.

		° ′	
1	1750--	4½ W.	A rough auxiliary value depending on observations about that time; see C. and Geod. Survey Bulletin No. 6. [$w=½$.—SCH.]
2	1794.0	0 51	John S. Lytle, county surveyor. Report of Secretary of Int. Affairs, State of Pa., 1884.
3	1840, July 30.	1 52.3	Dr. A. D. Bache; Coast Survey Report for 1862, App. 19.
4	1849, May 21.	1 59	Report of Secretary of Int. Affairs, Pa., 1876. Declination 1849.3, 3° 34′—1° 35′=1° 59′. Report, 2° 23′. [Mean, 2° 11′.—SCH.]
5	1852, April.	2 16	Report of the Secretary of Internal Affairs for 1884–'85, Harrisburg, 1886; J. S. Africa, secretary.
6	1858, September 10.	2 34	Report of Secretary of Int. Affairs for 1876. Decl'n 1858.7, 3° 34′—1° 00′=2° 34′.
7	1860, April 19.	2 41	Henry Wilson, county surveyor.
8	1874, August.	3 34	Report of the Secretary of Internal Affairs for 1884–'85, Harrisburg, 1886; J. S. Africa, secretary.
9	1879, August 19.	4 07	Letter from Hon. J. S. Africa to J. B. Kaufman, dated Jan. 17, 1881.
10	1880, September 24.	4 15.0	Report of Secretary of Int. Affairs for 1884–'85, Harrisburg, 1886; J. S. Africa, secretary.
11	1881, June 20.	4 23.4	Reference as before.
12	1883, April 9.	4 33.7	
13	1884, May 26.	4 37.5	
14	1885, December 24.	4 38.0 W.	

The values Nos. 2, 4, 6, 7, 9 were communicated by J. B. Kaufman, surveyor of Franklin Co., March 14, 1888.

Collection of Magnetic Declinations, etc.—Continued.

30.—NEW BRUNSWICK,* N. J.

$\phi=40° 29'.9$ $\lambda=74° 26'.8$ W. of Gr.

(Rutgers College.)

		° ′	
1	1800..	2 24 W.	Bearings of old lines taken by G. Hill.
2	1804..	2 30	Bearings of old lines taken by Jas. M. Cobb.
3	1811..	3 19	Bearings of old lines.
4	1814.6	3 07	Bearings of old lines taken by G. Hill.
5	1815.9	3 13	Bearings of old lines taken by G. Hill.
	1830.5	3 34(?)	Bearings of old lines taken by G. Hill. [Not used.—SCH.]
6	1836.6	4 40	Bearings of old lines taken by G. Hill.
7	1838.5	4 45	Bearings of old lines taken by G. Hill.
	1846.0	5 23(?)	Bearings of old lines taken by G. Hill. [Not used.—SCH.]
8	1848.6	5 10	Bearings of old lines taken by G. Hill.
9	1850.8	5 23	Bearings of old lines taken by G. Hill.
10	1863.0	6 09	Old deed reported by G. Hill.
11	1864..	6 10	Prof. G. H. Cook, at county meridian.
12	1866..	6 00(?)	T. N. Doughty.
13	1870..	6 24	Bearings of old lines.
14	1880..	7 15	Prof. E. A. Bowser.
15	1884..	7 30	Jas. M. Cobb.
16	1886..	7 30	Geo. Hill.
17 {	1887..	{ 7 32	Geo. Hill.
	1887.8	7 34 W.	Observed at Rutgers College and at several stations northward. [Mean, 7°.55 W. for 1887.7—SCH.]

* The data for this station are taken from the "Magnetic Survey of New Jersey" by George H. Cook, geologist in charge.

31.—JAMESBURG AND VICINITY,* N. J.

$\phi=40° 21'$ $\lambda=74° 27'$ W. of Gr.

		° ′	
1	1761..	4 33 W.	Henry M. Thomas from bearings of old lines.
2	1795..	3 11	
3	1799..	2 43	
4	1815..	3 12	
5	1826..	3 50	
6	1829..	3 52	
7	1887..	7 25 W.	

* The data for this station and vicinity are drawn from the "Magnetic Survey of New Jersey" by George H. Cook, State geologist in charge.

Collection of Magnetic Declinations, etc.—**Continued.**

32.—HARRISBURG, PA.

$\phi=40^\circ\ 15'.9$ $\lambda=76^\circ\ 52'.9$ W. of Gr.

(State Capitol.)

		° ′	
1	1795, August 19.	0 26 E.	From a map of the borough of Harrisburg, on file in office of register and recorder of this county, made by Thos. Foster. Communicated by W. W. Wright, March 10, 1875. [Weight assigned ¼.—Sch.]
2	1840, July 25.	3 12.5 W.	Dr. A. D. Bache; in the grounds east of the capitol; Coast Survey Report for 1862, p. 212. [Weight assigned ½.—Sch.]
3	1843--	2 35	From a map of the borough of Harrisburg, on file in the city register's office, made by John Roberts. Communicated by W. W. Wright, March 10, 1875.
4	1854, autumn.	3 06	John Roberts and Samuel Hoffer, surveyors; on true meridian established by them east of the State House. Communicated by W. W. Wright, Feb., 1875. [See also Annual Report of Sec'y of Int'l Affairs of Pa. for 1876.]
5	1857, April 29.	3 18.3	James Ferguson, James Aspach, and Daniel Hoffman, surveyors. Results recorded at county commissioners' office. Communicated by W. W. Wright, Feb., 1875.
	1857, June 3.	3 20	Samuel Hoffer; reference as before.
6	1860–'61.	3 30	From surveys made by Hather Page; map in city register's office at Harrisburg. Comm'd by W. W. Wright, March 10, 1875.
7	1862, July 28, 29.	3 44.5	C. A. Schott, asst. Coast Survey; grounds of the State House, near eastern entrance; Coast Survey Rep. for 1862, p. 212.
8	1874, October and November.	4 51	H. Alricks, jr., J. Simpson Africa; Annual Report of Sec'y of Int'l Affairs of Pa., 1876; W. McCandless, secretary.
9	1876, December 2.	5 10	Annual Report of the Secretary of State for 1876, as above.
10	1877, September 25, 26.	4 53.5	Edwin Smith, asst. Coast Survey; grounds east of the capitol, near astronomical station and near station of 1862, in $\phi=40^\circ\ 15'.8$, $\lambda=76^\circ\ 52'.9$ W.
11	1881, May 25.	5 17	J. B. Kaufman, county surveyor. At station in capitol grounds; declination corrected for diurnal variation. Letter of March 6, 1889.
12	1885, August 17, 18, 19.	5 21.9	J. B. Baylor, subasst. Coast and Geodetic Survey; station of 1877. MS. in Survey archives.
13	1883, Sept, and Oct.	5 31.2	J. S. Wall and J. H. Campbell at meridian line of 1877, capitol grounds. Rep. of Sec. of Int. Affairs of Pa. for 1888.
14	1889, February 21.	5 30.9 W.	J. B. Kaufman, county surveyor. At station in capitol grounds; declination corrected for diurnal variation. Letter of March 6, 1889.

Collection of Magnetic Declinations, etc.—Continued.

33.—HATBOROUGH, MONTGOMERY COUNTY, PA.

$\phi = 40° 12'$ $\lambda = 75° 07'$ W. of Gr.

		° ′	
1	1680..	8 28 W.	Table communicated to the Supt. of the Coast Survey by Mr. E. W. Beans, letter dated Hatboro', March 1, 1852. Coast Survey Report for 1855, p. 312. [It can not be supposed that this table presents results of direct observation, but it is most probably the result of some process of interpolation probably a graphical one. Mr. Beans expressed his entire confidence, in the accuracy of the data collected, and I do not doubt that the table is made up from reliable observations of numerous bearings of old and new lines. It should also be remembered that at the time this table was communicated, our knowledge of the secular variation was very imperfect, and that it was subsequently found to be in good accord with later researches. It is to be regretted that in consequence of Mr. Beans's demise nothing further could be learned of the series.—SCH.]
2	1690..	8 15	
3	1700..	7 55	
4	1710..	7 28	
5	1720..	7 00	
6	1730..	6 25	
7	1740..	5 35	
8	1750..	4 55	
9	1760..	4 00	
10	1770..	2 55	
11	1780..	2 05	
12	1790..	1 50	
13	1800..	1 55	
14	1810..	2 00	
15	1820..	2 27	
16	1830..	3 00	
17	1840..	3 50	
18	1850..	4 25 W.	

34.—PHILADELPHIA, PA.

$\phi = 39° 56'.9$ $\lambda = 75° 09'.0$ W. of Gr.

(State House.)

		° ′	
	1630, about.	11¼ W.	According to R. Dudley's Arcano del Mare, Florence, 1646–'47. [Not used.—SCH.]
1	1701..	8 30	Observed by Mr. Scull, according to G. Gillet, Sill. Jour., vol. xxiii, 1833.
2	1710..	8 30	Th. Whitney; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838.
3	1750..	5 45	Kalm's Travels; reference as above. [$w = \frac{1}{2}$.—SCH.]
4 {	1793..	1 30	Th. Whitney; reference as above.
	1793..	1 30	Mr. Brooks; Sill. Jour., vol. xxiii, 1833.
5	1802..	1 30	Mr. Howell; reference as above.
6 {	1804..	2 00	By several men of science; reference as before.
	1804..	2 10	Th. Whitney; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838.
7 {	1813..	2 25	D. McClure; reference as before.
	1813..	2 27	Th. Whitney; Sill. Jour., vol. xxiii, 1833.
8	1837..	3 52	W. R. Johnson; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838.
9	1840, June.	3 37	Dr. A. D. Bache, at Girard College Observatory; in $\phi = 39° 58'.3$, $\lambda = 75° 10'.3$ W. Annual change $= 4'.4$ from differential observations between June, 1840, and Dec., 1845; see Coast Survey Reports for 1859, p. 285, and for 1860, p. 311. [Subtracting $5'.3$ from the observed value of 1841 (see further on), we have for June, 1840, the value $+ 3° 48'$, and subtracting $26'$ from the observed value of 1846 (see further on), we have $+ 3° 26'$; the mean, or $+ 3° 37'$, is set down for June, 1840.—SCH.]
10	1841, July 20, November 1.	3 53.7 W.	Dr. A. D. Bache, at Girard College Observatory; Coast Survey Report for 1862; magnetic survey of Pennsylvania, p. 213.

Collection of Magnetic Declinations, etc.—Continued.

PHILADELPHIA, PA.—Continued.

		° ′	
11	1846, May 23.	3 51.1 W.	Dr. John Locke, Girard College Magnetic Obs'y; Coast Survey Report for 1854, p. 144.
12	1855, September 5.	4 31.7	C. A. Schott, assist. Coast Survey; grounds east of main building of Girard College, in $\phi = 39° 58'.4$, $\lambda = 75° 10'.2$ W.; Coast Survey Report for 1855, p. 337.
13	1862, August 15, 16.	5 00.0	C. A. Schott, assist. Coast Survey; at site of old magnetic observatory, Girard College; in $\phi = 39° 58'.4$, $\lambda = 75° 10'.2$ W.; Coast Survey Report for 1862, p. 212.
14	1872, October 19, 20, 21.	5 27.8	A. H. Scott, U. S. Coast Survey; at site of old magnetic observatory, Girard College; Coast and Geodetic Survey Report for 1881, App. 9. [$w = 2$—SCH.]
15	1877, October 2, 3, 5, 6.	6 02.2	J. B. Baylor, U. S. Coast Survey; SW. of main building of Girard College, in $\phi = 39° 58'.3$, $\lambda = 75° 10'.3$ W.; Coast and Geodetic Survey Report for 1881, App. 9. [Weight 2 assigned—SCH.]
16	1884, September 3, 10, 11.	6 21.6 W.	Edwin Smith, asst. Coast Survey; in the grounds of Girard College, near chapel, and near site of station of 1877; in $\phi = 39° 58'.3$, $\lambda = 75° 10'.3$ W. MS. in archives of the Survey. [Double weight assigned to this value.—SCH.]

35.—CHAMBERSBURG, FRANKLIN COUNTY, PA.

$\phi = 39° 55'$ $\lambda = 77° 40'$ W. of Gr.

		° ′	
1	1736, November 4.	4 15 W.	Zachary Butcher.
2	1744, September 11.	3 40	Thomas Cookson.
3	1746, March 25.	3 19	Thomas Cookson.
4	1754--	3 16	From land patent, on various lines, values varying between 2¾° and 4°. Not very reliable.
5	1768, May 6, November 1.	1 30	Col. John Armstrong, mean of 1° 15′ and 1° 45′ W.
6	1770, April 25.	1 30	Col. John Armstrong.
7	1786, March 31.	0 15 W.	Mathew Henderson.
8	1787, March 7.	0 15 E.	Mathew Henderson.
9	1794--	0 30	Mathew Henderson; mountain surveys.
10	1807-'8-'9.	0 42.5	Joseph Snively; values between 40′ and 45′ E.
11	1816, November 18.	0 30	Wm. S. Davis.
12	1818, May.	0 22	Wm. Cummins.
13	1822, November 21.	0 15	Wm. S. Davis.
14	1825, December 6.	0 00 E.	Wm. S. Davis.
15	1830, November 5.	0 15 W.	Wm. S. Davis.
16	1836, March 25.	0 27	Wm. S. Davis.
17	1840, August 24.	0 54.4	Dr. A. D. Bache, at Irwin's Mill near Mercersburg, in $\phi = 39° 47'$, $\lambda = 77° 56'$ W.; Coast Survey Report for 1862, App. 19. [Reduction to Chambersburg, +5′—SCH.]
18	1850, April 29.	1 30	John B. Kaufman; by means of an old, plain compass.
19	1852, April 12.	1 42	Observer and remark as before. [In annual report of the Secretary of Internal Affairs for Pa., Harrisburg. 1886, the value 1° 39′ W. is given.—SCH.]
20	1859, October 24.	2 12	John B. Kaufman; by means of a Gurley R. R. compass.
21	1863, March 25.	2 15	John B. Kaufman, notes a very small increase in declination between 1857 and 1863.

Collection of Magnetic Declinations, etc.—Continued.

CHAMBERSBURG, FRANKLIN COUNTY, PA.—Continued.

		° ′	
22	1864, March 31.	2 19 W.	Observer as before.
23	1865, June 1, 19.	2 24	
24	1866, February 23.	2 25	
25	1867, October to December.	2 35	
26	1869, May 24.	2 40	
27	1871, April, May, June.	2 55	
28	1873, April.	3 00	
29	1876, April.	3 15	
	1876, October.	3 10	Annual Report of Sec. of Int. Aff., Pa., 1876, Harrisburg, 1876. [Mean used.—SCH.]
30	1877, June.	3 20	John B. Kaufman; by means of a Gurley solar-transit.
31	1878, April 22.	3 24*	John B. Kaufman, at 4 p. m. [Reduction to mean of day, — 3′—SCH.]
32	1879, April 12.	3 31	John B. Kaufman, at 3 and 4 p. m. [Reduction to mean of day, —3′—SCH.]
33	1880, April 19.	3 36	John B. Kaufman, at 3½ p. m. Reduction to mean of day, —4′—SCH.]
34	1881, April 30.	3 41	John B. Kaufman, at 2 p. m. [Reduction to mean of day, — 5′—SCH.]
35	1882, April 29.	3 45	John B. Kaufman, between 11 and 12 a. m. [Reduction to mean of day, —2′—SCH.]
36	1883, April 30.	3 50.5	John B. Kaufman, between 3 and 4 p. m. [Reduction to mean of day, —4′—SCH.]
	1883, October 20.	3 47	*John B. Kaufman, at 9 a. m. and 2 p. m.*, at Upper Strasburg. [Mean of day adopted, 3° 47′ W.—SCH.]
37	1884, April 8.	3 49	John B. Kaufman, at 10 and 11 a. m. [In the Annual Rep. of the Sec'y of Int. Aff. for Pa., the additional value 3° 56′ W. is given.—SCH.]
38	1885, April 14.	3 53.5	John B. Kaufman, at 11 a. m., at county meridian.
	1885, July 8.	3 55.4	John B. Kaufman, from 20 obs'ns, ten direct and ten reversed, 1 to 2 p. m.; and 3° 53′.5 W. at 6 p. m., two obs'ns. [Corrected mean of 2 days adopted, 3° 52′.5 W.—SCH.]
39	1886, March 4.	3 54.0	John B. Kaufman, 3^h 25^m p. m.
	April 6.	3 56.2	John B. Kaufman, 2^h 40^m p. m., 20 ob's in 4 groups.
	April 27.	3 57.0	John B. Kaufman, 10^h 40^m a. m., at county meridian.
	June 4.	3 51.4	John B. Kaufman, 11 a. m., 5 ob's, at 7 a. m., 3° 44′.8, 20 obs'ns, and 3° 58′.9 at 2 p. m., from 11 ob's; at home meridian, Upper Strasburg, ϕ= 40° 03′, λ=77° 41′ W.
	October 1.	3 55.5	John B. Kaufman, at 3 p. m., 2 obs'ns, at county meridian, ϕ=39° 56′, λ=77° 39′ W. [Corr'd mean of 5 days adopted, 3° 53′.0 W.—SCH.]
40	1887, January 19.	3 59.2	John B. Kaufman, 11¾ a. m. to 1 p. m.; 11 direct and 15 reversed obs'ns.
	January 20.	3 57.6	John B. Kaufman, 11 a. m. and 3° 54′.1, at 9^h 15^m a. m. (11 d. and 12 r. obs'ns); 4° 01′.1, at 1 p. m. (4 obs'ns), and 4° 02′.4 at 3 p. m. (4 obs'ns).
	January 21.	3 53.0	John B. Kaufman, 5 obs'ns, at 10½ to 11 a. m., 4° 00′ at noon, 4° 01′ at 1 p. m, 4° 05′ at 3 p. m., and 4° 00′ at 5 p. m.
	January 22.	4 00.0	John B. Kaufman, at 11 a. m., 4° 05′ at 0 and 1 p. m., 4° 10′ at 3 p. m., 4° 00′ at 5 p. m.
	March 11.	4 00.5	John B. Kaufman, at 10½ a. m., and 4° 06′ at 2 p. m. [Corr'd mean of 5 days adopted, 4° 00′.0 W.—SCH.]
	April 26.	4 00.6 W.	John B. Kaufman, at county meridian. Mean of 10 compasses at 11^h a. m., 4° 00′.6 W. [Reduced to mean of day, +3° 59′.8, mean for 1887.12, +3° 59′.8—SCH.]

Collection of Magnetic Declinations, etc.—**Continued.**

CHAMBERSBURG, FRANKLIN COUNTY, PA.—Continued.

		° ′	
41	1888, January 18, February 2, 3, March 9, April 3–30, June 12, October 10.	4 02.4 W.	Observations by J. B. Kaufman and eleven other surveyors. Letters of March 4, July 10, 1888, and March 6, 1889. [Numerous observations at Upper Strasburg and at Chambersburg at various times of the day, reduced to mean of day were combined by me as follows: ° ′ Jan. 18 +4 00 Feb. 2 4 02 Feb. 3 4 02 Mar. 9 3 59.1 Apr. 3 4 06 Apr. 16 4 01.1 Apr. 17 4 04 Apr. 28 3 56 Apr. 30 4 03 June 12 4 01.3 (Jan. 18 to June 12: Mean, 4° 01′.5 W. for 1888.2) Oct. 10 4 03.4 Mean for 1888.5, +4°02′.4 W.—SCH.]
42	1889, January 31, March 6.	4 05.4 W.	John B. Kaufman, at Upper Strasburg. Observations corrected for diurnal variation. Letter of March 6, 1889. [Mean, +4° 05′.4 for 1889.1—SCH.]

Nearly the whole of the tabular results were obtained from Mr. John B. Kaufman, county surveyor, Franklin County, Pennsylvania, who communicated the same to me in a letter dated "Upper Strasburg, Pa., March 11, 1887." His table is headed "Declinations collected by John B. Kaufman, county surveyor, Franklin County, Pennsylvania, partly obtained by differentials between old and new bearings of trustworthy lines, partly by direct observations at the county meridian, latitude 39° 56′, longitude 77° 39′ W., and at the private meridian near Upper Strasburg, in latitude 40° 03′ and longitude 77° 41′ W., about." He further remarks: "From 1736 till 1852 (the declinations are) from land surveys, except the observation of Irwin's Mill; after 1852, partly by well-established lines compared with annual tests at county meridian, till 1876. Since last date observations were recorded from annual tests at private meridian. No correction made for diurnal variation."

36.—BALTIMORE, MD.

$\phi=39° 17'.8$ $\lambda=76° 37'.0$ W. of Gr.

(Washington Monument.)

		°			
	1630, about.	11(?) W.	According to R. Dudley's Arcano del Mare, Florence, 1646–'47. [Not used.—SCH.]		
			*Given values.** °		°
1	1679.0	5.25	D. of 1679.0=D. of 1814.5+4.50	Adopted value for later epoch.	+0.75
2	1683.5	6.25	D. of 1683.5=D. of 1814.5+5.50		+0.75
3	1703.5	5.12	D. of 1703.5=D. of 1811.8+4.43		+0.69
4	1720.5	4.21	D. of 1720.5=D. of 1816.0+3.42		+0.79
5	1729.2	4.02	D. of 1729.2=D. of 1807.1+3.39		+0.63
6	1754.5	2.28	D. of 1754.5=D. of 1855.5−0.37		+2.65
7	1756.9	2.88	D. of 1756.9=D. of 1815.0+2.12		+0.76
8	1771.0	1.11	D. of 1771.0=D. of 1846.5−1.00		+2.11
9	1776.1	1.75	D. of 1776.1=D. of 1811.4+1.07		+0.68
10	1780.5	0.77	D. of 1780.5=D. of 1861.5−2.25		+3.02
11	1787.5	0.37	D. of 1787.5=D. of 1851.0−2.00		+2.37
12	1808.5	0° 12′.5	D. Byrnes, from numerous observations at Baltimore, in different localities; Sill. Jour., vol. xviii, 1830.		
13	1840, August 27.	2 16.5 W.	Dr. A. D. Bache, Coast Survey Report for 1862, p. 213.		

Collection of Magnetic Declinations, etc.—Continued.

BALTIMORE, MD.—Continued.

		° ′	
14	1847, April 29.	2 18.6 W.	Capt. T. J. Lee, U. S. E., assistant Coast Survey, at Fort McHenry, in ϕ= 39° 15′.8, λ=76° 34′.8 W.; Coast Survey Report for 1854, p. 144.
15	1856, September 13.	2 29.3	C. A. Schott, assistant Coast Survey; just outside Fort McHenry; in ϕ= 39° 15′.9, λ=76° 34′.9 W.; Coast Survey Report for 1858, p. 191.
16	1875.5	3.74	D. of 1875.5=D. of 1857.0+1° 00. Adopted value for 1857.0+2°.74*
17	1877, October 10, 11, 12.	4° 10′.8	J. B. Baylor, U. S. Coast Survey, at Fort McHenry, near station of 1856, in ϕ=39° 15′.9, λ=76° 34′.9 W.; Coast and Geodetic Survey Report for 1881, App. 9.
18	1885, August 5, 6, 7.	4 29.3 W.	J. B. Baylor, subasst. Coast and Geodetic Survey, at Fort McHenry, station of 1877. MS. in archives of Survey.

* Mr. Thomas Kelbaugh, surveyor at Mount Carmel, Baltimore County, Maryland, communicated to the Coast Survey Office (letters dated August 17 and 24, 1877, and April 28, 1879) 52 cases of observed (or allowed for) changes of magnetic declinations between two given dates. These differences were mostly from redeterminations of magnetic bearings of old lines made with the common surveyor's compass, by different individuals and with different instruments. Their locality was generally within a radius of 15 statute miles of the city of Baltimore, and on the N., the NE., and NW. of it. These surveys were made by order of the Baltimore County circuit court, in consequence of disputed land boundaries. Other values Mr. Kelbaugh copied from the record books of the county surveyor and his assistants, between 1805 and 1825.

[These 52 differential values were carefully scrutinized by me and finally combined to 12 mean results, as given in the above table results Nos. 1 to 11 inclusive and No. 16. To these several differences I have added the respective values adopted by me for the declination at the time of the resurvey. These latter data resulted from a formula for Baltimore as established by me in 1877.—SCH.]

37.—WASHINGTON, D. C.

ϕ=38° 53°.3 λ=77° 00′.6 W. of Gr.

(U. S. Capitol, dome.)

		° ′	
1	1750--	2½ W.	A rough auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6. [A compromise value, considering the observation at Baltimore. w=⅓—SCH.]
	1792--	0 51 E.	Major A. Ellicott, surveyor-general; inscription on fourth mile-stone, northwesterly from east corner of District; reported by G. Mathiot. [Not used; supposed locally affected.—SCH.]
2	1792--	0 19 E.	Major A. Ellicott; inscription on first mile-stone northwesterly from east corner of District; reported by John Wiessner.
	1792--	0 10 E.	Major A. Ellicott; inscription on east corner-stone of District; reported by J. Wiessner; in ϕ=38° 53′.6, λ=76° 54′.6 W. [Mean—0°.24—SCH.]
3	1809, December	0 52 W.	Nicholas King, surveyor for the city of Washington; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838. [w=½—SCH.]
4	1841.0	1 20.2	J. M. Gilliss, U. S. N.; on Capitol Hill, north of the Capitol; in ϕ=38° 53′.7, λ=77° 00′.6; Sen. Doc. 2d sess., 28th Congress, 1844–'45.
5	1842.0	1 23.9	J. M. Gilliss, U. S. N.; place and reference as before.
6	1855, July.	2 24	C. A. Schott, assist., Coast Survey; on Capitol Hill, near Gilliss's station; in ϕ=38° 53′.6, λ=77° 00′.6 W.; Coast and Geodetic Survey Report for 1881, App. 9.
7	1856, August 14, 20.	2. 21.4	C. A. Schott, assist. Coast Survey; near old office building on Capitol Hill; in ϕ=38° 53′.1, λ=77° 00′.6 W.; reference as before.
	1856, August.	2 00.9 W.	C. A. Schott; in park east of the Capitol, in ϕ=38° 53′.3, λ=77° 00′.5 W.; reference as before. [Not used.—SCH.]

Collection of Magnetic Declinations, etc.—**Continued.**

WASHINGTON, D. C.—Continued.

		° ′	
8	1857, March 9.	2 24.8 W.	W. Reed; near Capitol, south side; Coast Survey Report for 1858, p. 196. Communicated by observer.
9	1860, August 16 to September 26.	2 26.7	C. A. Schott; near Coast Survey Office (old building), in ϕ=38° 53′.1, λ=77° 00′.6 W.; Coast and Geodetic Survey Report for 1881, App. 9.
10	1862, August 18, 19.	2 39.4	Observer, locality, and reference as before.
11	1863, June 18 to July 28.	2 41.8	Observer, locality, and reference as before.
12	1866, November 1.	2 44.2	Prof. W. Harkness, U. S. N.; grounds of the U. S. Naval Observatory, in ϕ=38° 53′.7, λ=77° 03′.1 W.; Smithsonian Contributions to Knowledge, No. 239, p. 61, Washington, 1873.
13	1867, January to December.	2 48.1	C. A. Schott; at magnetic observatory, corner 2nd and C streets S. E., Capitol Hill, in ϕ = 38° 53′.1, λ = 77° 00′.2 W.; monthly determinations, Coast Survey Report for 1869, pp. 199–207.
14	1868, January to December.	2 51.2	
15	1869, January to June, inclusive.	2 53.0	
16	1870, June 13, 14, 15.	2 53.6	C. A. Schott; at magnetic observatory, corner 2nd and C streets S. E.; Coast Survey Report for 1870, App. 14.
17	1871, June 14, 15, 16.	2 56.9	
18	1872, June 14, 15, 17.	3 00.0	
19	1873, June 14, 16, 17.	3 00.1	Observer and locality as before.
20	1874, June 13, 15, 16.	3 07.4	Coast and Geodetic Survey Report for 1881, App. 9.
	1874, July 20, 21, 22.	3 05.2	[Mean for 1874.5, 3° 06′.3—SCH.]
21	1875, June 12, 14, 15.	3 15.5	Observer, locality, and reference as before.
22	1876, May 1 and 2.	3 18.8	
23	1877, June 14, 15, 16.	3 42.1	C. A. Schott; at new magnetic observatory, near corner of First and B sts. S. E., Capitol Hill, in ϕ = 38° 53′.2, λ = 77° 00′.4 W.
	1877, August 17.	3 36.8	A. Braid; U. S. Coast Survey; same locality and reference.
24	1878, June 14, 15, 17.	3 47.5	C. A. Schott; locality and reference as before.
	1878, September 8.	3 43.0	Dr. T. E. Thorpe; locality as above; reference as before.
25	1879, June 9, 10, 11.	3 50.4	Wm. Eimbeck and C. A. Schott, assists. Coast Survey; locality and reference as before.
26	1880, February 23, 24, 25.	3 52.4	Marcus Baker, U. S. Coast and Geodetic Survey; locality as before. MS. in archives.
	1880, April 3.	3 57.2	J. B. Baylor; U. S. Coast and Geodetic Survey; locality as before; Coast and Geodetic Survey Report for 1881, App. 9. [Mean, + 3°.92—SCH.
	1880, June 12, 14, 17.	3 57.1	
27	1882, June 15, 16, 17.	3 55.4	W. Eimbeck, assist. Coast and Geodetic Survey; locality and reference as before.
28	1883, June 18, July 5.	4 00.2	C. A. Schott, assist. Coast Survey; locality as before. MS. in archives.
29	1884, February 5, 7.	3 57.9	J. E. Maxfield, sergeant U. S. Signal Corps; locality and reference as before.
	1884, June 16, 17.	4 05.2	C. A. Schott; locality and reference as before. MS. in archives.
30	1885, June 13, 15.	4 11.5	
31	1886, June 14, 15, 16.	4 08.7	
32	1887, July 28, 29.	4 05.0	J. B. Baylor; station in vacant lot just south of new office building (C. and G. S., 1871), close to station of 1856 and 1857, in ϕ = 38° 53′.2, λ = 77° 00′.5. MS. in archives.
33	1888, June 19, 20.	4 08.8	J. B. Baylor; locality as above. MS. in archives.
34	1889, Sept. 24, 25, 26.	4 15.1 W.	E. D. Preston; locality as above. MS. in archives.

Collection of Magnetic Declinations, etc.—Continued.

38.—CAPE HENLOPEN, DEL.

$\phi = 38° 46'.7$ $\lambda = 75° 05'.0$ W. of Gr.

(Light-house.)

		° ′	
	1609, October 4.	6 W.	Hudson; on the coast of New Jersey, in $\phi = 39° 30'$ } Prof. E. Loomis's collection in Sill. Jour., vol. xxxix, 1840. [The mean latitude is 38° 51′, and the declination may be taken at 7½° W. with an estimated probable error of ± 3° at least. It is of very little weight. Not used.—SCH.]
	1609, August 12.	10	Hudson; off the coast of Maryland, in $\phi = 38° 13'$ }
	1630, about.	10½	According to R. Dudley's Arcano del Mare, Florence, 1646–'47. [Not used.—SCH.
1	1700.0	6	Edm. Halley; Tabula Nautica Variationum Magneticarum, etc. Reproduced by photolithography in the Greenwich observations for 1869. [$w = ½$—SCH.]
2	1750..	3½	A rough auxiliary value depending on observations made about this period; see C. and Geod. Survey Bulletin No. 6. [$w = ½$—SCH.]
3	1795..	0 55	From Aurora; at Lewiston, in $\phi = 38° 46'$, $\lambda = 75° 08'$ W. Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838. [Position corrected by me.—SCH.]
4	1833.0	1 15	Peter Barlow's isogonic map of 1833; Phil. Trans. Roy. Soc., 1833. [On this map the *name* Cape Henlopen is erroneously placed.—SCH.]
	1841, May.	4 42	Barnett; Phil. Trans. Roy. Soc., 1841. [Not used.—SCH.]
5	1843, October and November.	2 26.0	S. P. Lee, U. S. N., act'g assist. Coast Survey; near the light-house; Coast and Geodetic Survey Report for 1881, App. 9.
6	1846, July 1.	2 45.0	Dr. John Locke, act'g, assist. Coast Survey; at Lewis's landing, in $\phi=38° 48'.8$, $\lambda=75° 11'.9$ W.; reference as above.
7	1856, August 27.	3 03.9	C. A. Schott, assist. Coast Survey; near and southwest of the light-house, in $\phi=38° 46'.5$, $\lambda=75° 05'.3$ W.; reference as above.
8	1885, July 29, 30, 31.	4 59.6 W.	J. B. Baylor, subassist. Coast and Geodetic Survey; near light-house, in $\phi=38° 46'.7$ $\lambda=75° 05'.2$ W. [Weight = 2—SCH.] MS. in archives of the Survey.

39.—WILLIAMSBURG, JAMES CITY COUNTY, VA.

$\phi=37° 16'.2$ $\lambda=76° 42'.4$ W. of Gr.

		° ′	
1	1694..	5 W.	Bishop Madison, president of William and Mary College; in $\phi=37° 13$, $\lambda=76° 35'$ W.; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv. 1838.
2	1750..	1 56	A rough auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6.
3	1780..	0 50 W.	Bishop Madison, president of William and Mary College; in $\phi=37° 15'$, $\lambda=76° 35'$ W.; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838.
4	1809..	0 33 E.	
5	1840, January.	0 45 W.	Lieut. Col. Edw. Sabines's isogonic chart for Jany., 1840, in Phil. Trans. Roy. Soc. for 1849, part 1.
6	1874, December 4–9.	2 12	J. B. Baylor, U. S. Coast Survey. In the grounds of the W. & M. College. $\phi=37° 16'.3$, $\lambda=76° 42'.7$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
7	1887, April 9, 11, 12.	3 02.9 W.	J. B. Baylor, assist. C. and Geod. Survey. Position as before. MS. in archives.

Collection of Magnetic Declinations, etc.—Continued.

40.—CAPE HENRY, VA.

$\phi=36°\ 55'.6$ $\lambda=76°\ 00'.4$ W. of Gr.

(Light-house.)

		° ′	
1	1700.0	4 W.	Edm. Halley's Tabula Nautica Variationum Magneticarum, etc.
2	1728, March 6	3	W. Byrd; at head of Currituck Sound, in $\phi=36°\ 33'$. The Westover MS. [Reduction to cape +20′, about.—SCH.]
3	1732..	4 42	W. Hoxton; seven miles from Cape Henry, in $\phi=36°\ 50'$. Hansteen's Magnetismus der Erde, 1819. [Probable reduction to cape −10′—SCH.]
	1732..	4 40	Douglass's History; in $\phi=37°\ 07'$, $\lambda=75°\ 50'$ W. Prof. E. Loomis's collection, in Sill. Jour., vol. xxxiv, 1838. [This is supposed the same as Hoxton's obs'n; not used.—SCH.]
4	1750..	1 47	A rough auxiliary value depending on observations about that period; see C. and Geod. Survey Bulletin No. 6.
	1775..	5 00	J. F. W. Des Barres's Atlantic Neptune, London, 1781. [Not used.—SCH.]
5	1809..	0 00	President Madison, at Norfolk, in $\phi=36°\ 51'$, $\lambda=76°\ 19'$ W. Prof. E. Loomis's collection, in Sill. Jour., vol. xxxiv, 1838. [Reduction to cape −4′ by obs'ns in 1856, but too doubtful to apply.—SCH.]
	1823–'24.	1 32	H. Boye's State map of Va., of 1859. [Not used.—SCH.]
6	1832, June 9, 11.	0 45	Prof. J. N. Nicollet; Coast Survey Report for 1864, p. 210.
7	1856, September 11, 12.	1 28	C. A. Schott, assist. Coast Survey; near the light-house, in $\phi=36°\ 55'.6$, $\lambda=76°\ 00'.4$ W.; Coast Survey Rep. for 1856, p. 227.
8	1874, November 26, 27, 28.	2 39.5	Dr. T. C. Hilgard, observer for U. S. Coast Survey; near the light-ho.; Coast and Geodetic Survey Report for 1881, App. 9.
9	1879, May and June.	2 32	Lt. S. W. Very, U. S. N.; from 50 observations at the Rip Raps, in $\phi=36°\ 59'.0$, $\lambda=76°\ 18'.4$ W. MS. communication. [Reduction to Cape Henry about +10′—SCH.]
10	1881, June 16.	3 11	Lieut. C. P. Perkins, U. S. S. Alliance; in $\phi=37°\ 00'$, $\lambda=76°\ 10'$ W.; Naval Professional Papers, No. 19. [Reduction to cape +5′, about.—SCH.]
11	1883, January 2.	3 10	Lieut. G. A. Norris, U. S. S. Enterprise; in $\phi=36°\ 56'$, $\lambda=76°\ 06'$ W.; reference as before. [Reduction to cape about +5′—SCH.]
	1883, June 30.	3 06	Lieut. C. Belknap, U. S. S. Vandalia; in $\phi=36°\ 57'$, $\lambda=76°\ 02'$ W.; reference as before. [Reduction to cape about zero.—SCH.]
	1883, August 29.	3 35	Lieut. H. W. Lyon, U. S. S. Galena; in $\phi=36°\ 54'$, $\lambda=75°\ 54'$ W.; reference as before. [Reduction to cape about −5′—SCH.]
	1883, December 10.	3 39	Lieut. C. Belknap, U. S. S. Vandalia; in $\phi=36°\ 56'$, $\lambda=75°\ 57'$ W.; reference as before. [Reduction to cape about zero; mean, +3° 22′ for 1883.5—SCH.]
12	1884, May 10.	3 37	Lieut. F. Hanford, U. S. S. Pensacola; in $\phi=36°\ 54'$, $\lambda=75°\ 45'$ W.; reference as before. [Reduction to cape about −15′—SCH.]
	1884, October 10.	2 55	Lieut. C. C. Cornwell, U. S. S. Powhatan; in $\phi=37°\ 00'$, $\lambda=76°\ 06'$ W.; reference as before. [Red'n to cape about +5′; mean, +3° 11′ for 1884.5—SCH.]
13	1887, April 14, 15, 16.	3 20.1 W.	J. B. Baylor, asst. C. and Geod. Survey. Near old light-house as in 1874; in $\phi=36°\ 55'.6$, $\lambda=76°\ 00'.4$. MS. in archives.

Collection of Magnetic Declinations, etc.—Continued.

41.—NEW BERNE, N. C.

$\phi=35^\circ\ 06'$ $\lambda=77^\circ\ 02'$ W. of Gr.

		° ′	
1	1750..	0.29 E.	A rough auxiliary value depending on observations made about that time; see C. and Geod. Survey Bulletin No. 6.
2	1796..	2 40	Jonath. Price; from Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838; position assigned $\phi=35^\circ\ 20'$, $\lambda=77^\circ\ 05'$ W. [Latitude 14′ too high.—SCH.]
3	1806..	2 00	
4	1809..	1 45 E.	
5	1840.0	0 00	Lieut. Col. Edw. Sabine; isogonic chart for 1840, Jan'y; Phil. Trans. Roy. Soc., 1849, part i.
6	1874, December 21, 23, 24.	1 20.4 W.	J. B. Baylor, aid U. S. Coast Survey; at cemetery in $\phi=35^\circ\ 07'.4$, $\lambda=77^\circ\ 03'.3$ W.; Coast and Geodetic Survey Report for 1881; App. 9.
7	1887, March 19, 20.	1 54.4 W.	J. B. Baylor, asst. C. and Geod. Survey. In national cemetery, as before. MS. in archives. [$w=1\frac{1}{2}$—SCH.]

42.—MILLEDGEVILLE, GA.

$\phi=33^\circ\ 04'.2$ $\lambda=83^\circ\ 12'$ W. of Gr.

		° ′	
1	1750..	2.05 E.	A rough auxiliary value depending on observations about this time; see C. and Geod. Survey Bulletin No. 6.
2	1805..	5 30	J. Bethune; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838. Position assigned, $\phi=33^\circ\ 07'$, $\lambda=83^\circ\ 20'$ W.
3	1835..	4 40	Observer and reference as above. [$w=\frac{1}{2}$—SCH.]
4	1838..	5 51	Geological Survey of Georgia; Prof. E. Loomis's collection in Sill. Jour., vol. xxxix, 1840. Position assigned, $\phi=33^\circ\ 07'$, $\lambda=83^\circ\ 20'$ W. [$w=\frac{1}{2}$—SCH.]
5	1875, June 15.	4 14.1	J. M. Poole, Bache-Fund observer to National Academy of Sciences; Coast and Geodetic Survey Report for 1882, App. 14, pp. 402 and 425; in the old Capitol grounds. [This value is one of two obtained by the observer, and one of these is probably affected by a misreading of 1°; the value given by me is the first one, taken from the MS. computation.—SCH.]
6	1887, March 8, 9.	3 36.4 E.	J. B. Baylor, asst. C. and Geod. Survey; in grounds of the Capitol, $\phi=33^\circ\ 04'.2$, $\lambda=83^\circ\ 10'$. MS. in archives.

43.—CHARLESTON, S. C.

$\phi=32^\circ\ 46'.6$ $=79^\circ\ 55'.8$ W. of Gr.

(St. Michael's Church.)

		° ′	
1	1700.0	0 30 E.	Edm. Halley's isogonic chart for 1700, reproduced by photolithography in the Greenwich observations for 1869. [Weight $\frac{1}{2}$ in discussion.—SCH.]
	1742..	5 23	English Pilot, published at Tower Hill in 1794; extracted from a paper by Andrew Hughes. [Not used.—SCH.]
2	1750..	1 39	A rough auxiliary value depending on observations made about this period; see C. and Geod. Survey Bulletin No. 6.
3	1775..	3 48 E.	J. F. W. Des Barres's Atlantic Neptune, London, 1781.

Collection of Magnetic Declinations, etc.—Continued.

CHARLESTON, S. C.—Continued.

		° ′	
	1777..	3 48 E.	From a chart. Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838. [Supposed the same as that given in the Neptune; not used.—SCH.]
4	1784, February.	5 15	Joseph Purchell, surveyor. From a pamphlet by Charles Parker, Charleston, 1849. Observations said to come from a reliable source.
5	1785, October.	5 45	
6	1824–'25.	3 45	Lieut. Sherburne, U. S. N.; Blunt's chart of 1824–'25.
7	1833.0	4 00	Peter Barlow; isogonic chart for 1833. Phil. Trans. Roy. Soc., 1833, part I.
8	1837..	2 54	Capt. Missroom; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838. Position in $\phi=32° 47'$, $\lambda=79° 57'$ W.
9	1840..	2 44	Dr. C. Davies, in his treatise on surveying.
10	1841, May.	2 24	Barnet, Phil. Trans. Roy. Soc., vol. for 1849.
11	1847, October.	2 15	Charles Parker; from a pamphlet published by him at Charleston, 1849.
12	1849, April 1–22.	2 16.5	C. O. Boutelle, assist. Coast Survey; at Breach Inlet, on Sullivan's Island, in $\phi=32° 46'.3$, $\lambda=79° 48'.9$ W.; Coast Survey Report for 1854, p. 145.
13	1874, May 27, 28, 29.	0 58.2	C. O. Boutelle, asst. Coast Survey; at Fort Marshall, near Breach Inlet, in $\phi=32° 46'.4$, $\lambda=79° 48'.8$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
14	1880, Jnauary 21, 22.	0 25.6	J. B. Baylor. U. S. Coast and Geodetic Survey; position and reference as before.
15	1885, December 29, 30.	0 14.2 E.	J. B. Baylor, subassist. Coast and Geodetic Survey; near Breach Inlet, Sullivan's Island, in $\phi=32° 46'.3$, $\lambda=79° 48'.9$ W. MS. in archives of the Survey.

44.—SAVANNAH, GA.

$\phi=32° 04'.9$ $\lambda=81° 05'.5$ W. of Gr.

(Savannah Exchange.)

		° ′	
1	1750..	2.21 E.	A rough auxiliary value depending on observations about this period; see C. and Geod. Survey Bulletin No. 6.
2	1817..	4	Becquerel's Traité du Magnétisme, Paris, 1846; Cartes du Dépôt; in $\phi=32° 04'$, $\lambda=81° 05'$ W.
3	1833.0	5 00	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., 1833, part I.
4	1838..	5 05	Geological Survey; in $\phi=32° 05'$, $\lambda=81° 07'$ W.; Prof. E. Loomis's collection in Sill. Jour., vol. xxxix, 1840.
5	1839..	3 31	Dr. Posey; reference as before.
6	1852, April 26, 27, 28.	3 40.3	J. E. Hilgard. asst. Coast Survey; on Hutchinson's Island, opposite Savannah, in $\phi=32° 05'.2$, $\lambda=81° 05'.3$ W.; Coast and Geodetic Survey Report for 1881, Appendix 9.
7	1857, May 1, 2.	3 27.5	C. A. Schott, asst. Coast Survey; position as in 1852; Coast and Geodetic Survey Report for 1881, Appendix 9.
8	1874, March 8, 9, 10.	2 16.9	F. Blake and C. Tappan, observers for U. S. Coast Survey; position as in 1852 and 1857; reference as above.
9	1886, January 6, 7.	1 37.2 E.	J. B. Baylor, subasst. U. S. Coast Survey; on Hutchinson's Island; position as above. MS. in archives of Survey.

Collection of Magnetic Declinations, etc.—**Continued.**

45.—PARIS, FRANCE.

$\phi = 48° 50'.2$ $\lambda = 2° 20'.2$ E. of Gr.

(Paris Astro'l Observatory.)

		° ′		
1*	1541..	7	E.	Bellarmatus.
2	1550..	8		Orontius Finæus (Oronce Finné).
3	1580..	11 30		Sennertus.
4	1603..	8 45		Nantonnier.
5	1610..	8 00		Nantonnier.
6	1630..	4 30		Petit.
7	1642..	2 30		Petit.
8	1659 and 1660.	1 30		(?)
9	1664..	0 40	E.	Picard.
10	1666 and 1667.	0 08	W.	
11	1670..	1 30		
12	1680–81–82–83–84.	3 08		Picard and La Hire.
13	1685–86–87–88–89.	4 52		La Hire and Cassini.
14	1691–92–93–95–96–97–98.	6 37		La Hire and Cassini. [Mean of 2 values of 1698 included.—SCH.]
15	1699, 1700–1–2–3–4, 1705, –6–7.	9 00		La Hire and Cassini. [Includes mean of 2 values each for 1700–1–2–3–4, and of 3 values for 1705.—SCH.]
16	1708–9–10–11–12–13–14–15–16.	11 11		La Hire and Cassini. [One value for 1715, 3 for 1716, and 2 values each for other years.—SCH.]
17	1717–18–19–20–21–22–23 –24–25.	12 52		Cassini, La Hire, and Maraldi. [Two values for 1717–18–21–22–23, 3 for 1725, and 1 for 1719–20–24.—SCH.]
18	1726–27–28–29–30–31–32 –33–34.	14 37		Maraldi and Buache. [Two values for 1734.—SCH.]
19	1735–36–37–38–39–40–41 –42–43.	15 23		Maraldi and Cassini. [Two values for 1735–36–38–40–42 each.—SCH.]
20	1744–45–46–47–48–49–50 –51–52.	16 37		Fouchy.
21	1753–54–55–57–58–59–60.	17 49		Maraldi.
22	1765..	19 00		
23	1770–71–72–73–74.	20 01		Maraldi and Le Monnier. [Two values each for 1772–73–74.—SCH.]
24	1777–78–79–80–81.	20 40		Le Monnier. [Two values for 1778, 6 for 1779, 46 for 1780, and 12 for 1781.—SCH.]
25	1782–83–84–85–86.	21 25		Le Monnier. [Three values for 1782–83 each, and 2 for 1784–86 each.—SCH.]
26	1789–90–91–92–93.	22 18		Le Monnier. [Two values for 1790–91 each.—SCH.]
27	1798–99–1800–01.	22 14		Le Monnier. [Two values for 1799.—SCH.]
28	1802–3–4.	21 58		Le Monnier, Bouvard, and Cotte. [Three values for 1802.—SCH.]
29	1805..	22 05		Cotte; E. Walker, in "Terrestrial and Cosmical Magnetism," Cambridge, 1866.
30*	1807..	22 34		Bouvard.
31	1810, March 13, 1 p. m.	22 16		Observations by Arago; Walker's Ter. and Cos. Magnetism, Cambridge (Eng.), 1866. [Mean of 4 values, 22° 24′.5; same corrected for diurnal variation, 22° 20′; epoch, 1812.2—SCH.]
	1811, October 15, noon.	22 25		
	1812, October 9, 2½ p. m.	22 29		
	1813, October 30, noon.	22 28	W.	

* The values Nos. 1 to 30, inclusive, between 1541 and 1807, except for 1805, were taken from the article "Magnetism," by Peter Barlow, in the Encyclopædia of Experimental Philosophy (a part of the Ency. Metropolitana), London, 1848. [These values were combined by me into suitable groups, and their means were taken as indicated in the table.—SCH.]

Collection of Magnetic Declinations, etc.—**Continued.**

PARIS, FRANCE—Continued.

		° ′	
32	1814, August 10, noon.	22 34 W.	Observations by Arago; Walker's Ter. and Cos. Magnetism, Cambridge (Eng.), 1866. [Mean of 3 values, 22° 26′.0; same corrected for diurnal variation, 22° 22′; epoch, 1816.5—SCH.]
	1816, October 12, 3 p. m.	22 25	
	1817, February 10, 0½ p.m.	22 19	
33	1823	22 23	A. Guyot, in Johnson's Universal Cyclopædia, Art. Earth, New York, 1876. [Mean of 4 values, 22° 15′, for 1827.2—SCH.]
	1827	22 20	
	1828	22 05	
	1829	22 12	
34	1835.5	22 04	Arago; Gen. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., vol. for 1872, part II; in $\phi = 48° 53'$, $\lambda = 2° 20'$ E.
35	1838, February.	21 38	Darondeau; Phil. Trans. Roy. Soc., 1849, part II.
36	1842.5	21 29	Lamont; Gen. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., vol. for 1872, part II.
37	1858, January 1.	19 36.3	Rev. S. J. Perry; Magnetic survey of the east of France; Phil. Trans. Roy. Soc., vol. for 1872, London, 1873.
38	1865	18 44	Encyclopædia Britannica, 9th edition, 1877, Art. Compass.
39	1869, September 1.	17 08.4	Rev. S. J. Perry; Magnetic survey of the east of France; reference as for No. 37.
40	1875, July.	17 21	Jordan's Vermessungskunde, Vol. 1, Stuttgart, 1877.
41	1879, January 1.	16 56	Annuaire pour l'an 1882, Paris.
42	1885, January to December.	16 06.9	Parc Saint Maur; Th. Moureaux, observer; Comptes Rendus de l'Académie, June, 1886; in $\phi = 48° 48'.6$, $\lambda = 2° 29'.6$ E. Annual change, 7′.4 losing. [For these values, and their reduction to Paris by the addition of the constant 4′.8, I am indebted to the courtesy of M. Moureaux, who communicated them in his letter of Feb. 1, 1887; see also Mémoires divers pendent l'année 1885, and Annales of Observatory, 1886. The values, reduced to Paris, are therefore 16° 11′.7, 16° 05′.7, and 16° 02′.0, respectively.—SCH.]
43	1886.5	16 00.9	
44	1887.0	15 57.2	
45	1888.5	15 52.1 W.	"Nature," of Dec. 13, 1888. [Reduced to Paris, 15° 56′.9—SCH.]

46.—BERMUDA ISLANDS.*

$\phi = 32° 22'.6$ $\lambda = 64° 42'.6$ W. of Gr.

(Signal station, St. George's Town.)

		° ′	
1	1831	6 59 W.	Austin and Foster; Sir Edw. Sabine, in Phil. Trans. Roy. Soc., 1874, Cont'n xiv. In $\phi = 32° 23'$, $\lambda = 64° 47'$ W.
2	1837	6 40	Milne; reference as before.
3	1845, October.	7 01	Capt. Barnett, Roy. Eng's; Bermuda Royal Gazette; at signal station; in $\phi = 32° 23'$, $\lambda = 64° 40'$ W.
4	1846	6 53	Capt. Barnett, Roy. Eng's; Sir Edw. Sabine, in Phil. Trans. Roy. Soc., 1874, Cont'n xiv. In $\phi = 32° 23'$, $\lambda = 64° 47'$ W.

* According to the "Arcano del Mare," the declination about 1630, to the south of the islands, was about 11¼° West. [SCH.]

Collection of Magnetic Declinations, etc.—Continued.

BERMUDA ISLANDS—Continued.

		° ′		
5	1873, May 13.	7 10	W.	H. M. S. Challenger; Green outside dockyard, in ϕ=32° 19′.2, λ=64° 51′.8 W. Results of the Voyage of H. M. S. Challenger; Narrative, vol. ii, London, 1882.
	1873, April 12.	7 15		H. M. S. Challenger; St. George, Button Island, in ϕ=32° 22′.6, λ=64° 42′.6 W. Results of the Voyage of H. M. S. Challenger, Narrative, vol. ii, London, 1882, pp. 25 and 46. [According to Staff Commander E. W. Creak, R. N. ("On Local Magnetic Disturbance in Islands situated far from a Continent," Proceedings of the Royal Society, No. 242, 1886), the position on the Green outside dockyard appears to be the only one that may be taken as free from disturbing local attraction; I have therefore transcribed this and the result at St. George's, omitting the Challenger results at other stations on the Bermudas. Commander Creak assumes 2′ increase for the annual change about this time.—Sch.]
6	1876..	7 45	W.	Brit. Admiralty Chart No. 360, Feb., 1877; annual increase of declination about 3′.

47.—RIO DE JANEIRO, BRAZIL.*

ϕ=—22° 54′.8 λ=43° 09′.5 W. of Gr.†

(Flag-staff at Fort Villegagnon.)

		° ′		
1	1768, October.	7 34	E.	Cook ...... } Voyages of the Adventure and Beagle, 1826–'36, Vol. 1, Capt. P. P. King, London, 1839, p. 523. Discussion by Major Sabine. For reference to Cook and Hunter, see also Hansteen's Magnetismus der Erde, Christiania, 1819.
2	1787..	6 12		J. Hunter... }
3	1820..	2 54		Freycinet... }
4	1821..	3 21		Rumker..... }
5	1830, May 23, 25, 26; June 2, 5, 13.	2 08.4		A. G. Erman, Reise um die Erde, etc., Berlin, 1835. In ϕ=—22° 53′.9, λ=43° 05′.2 W.
6	1836..	2 00	E.	Capt. Fitz Roy; Voyages of the Adventure and Beagle, 1826–'36, London, 1839.
7	1857..	1 20	W.	Capt. E. O. Stanley and G. R. Richards and Lieut. Bullock, R. N.; Admiralty Chart No. 541. Fort Villegagnon, in = — 22° 54′.7, λ=43° 09′.0 W.
8	1866, January 8.	2 41.8		W. Harkness, Prof. U. S. N.; position near north face of Fort Caraguata, in ϕ=— 22° 54′.1, λ=43° 06′.5 W. Smithsonian Contributions to Knowledge No. 239, Washington, 1873, p. 61.
9	1876.5	4 26		Lieut. S. W. Very, U. S. N. From numerous observations at various times and different places. [MS. communication to me, dated Dec. 13, 1879—Sch.]
10	1882, August 3.	4 39	W.	Annales du Bureau des Longitudes, tome iii, Paris, 1883, p. 396–97. [At this place the secular change is progressing perhaps at the most rapid rate known within the tropics and close to the magnetic equator. In a pamphlet published in 1594, entitled "The Seaman's Secret," the celebrated navigator John Davis notes, under the head of remarks, after leaving Brazil, "the compass varies 9°, the *south* pointing *westward*." (Encycl. Brit., 9th edition, 1884, Art. Navigation.)—Sch.]

* According to the "Arcano del Mare," the declination about 1630, off this port, was nearly 1° East. [Sch.]

† Longitude from "telegraphic determinations of longitude;" Lieut. Comdr's Green and Davis, U. S. N., 1878–'79, Washington, D. C., 1880.

RESULTS FOR GROUP I.—Magnetic stations on the eastern coast of the United States and inclusive of the region of the Appalachian range, with some additional stations in Newfoundland and other foreign localities.

In the last column, below, of the expressions for the secular variation of the magnetic declination, the letter D stands for declination, a plus sign indicating west, a minus sign east declination. The letter m stands for t—1850.0 or for the difference in time, expressed in years and fraction of a year, for any time t and the middle of the century; it is to be taken within the range of observations at any station.

No.	Name of station and State.	Latitude.	West longitude.	The magnetic declination expressed as a function of time.
		° ′	° ′	° ° °
1	Saint John's, Newfoundland.	47 34.4	52 41.9	$D=+21.94+8.89\sin(1.05\,m+63.4)$*
2	Quebec, Canada.	46 48.4	71 14.5	$D=+14.66+3.03\sin(1.4\,m+4.6)$ $+0.61\sin(4.0\,m+0.3)$
3	Charlottetown, Prince Edward Island.	46 14	63 27	$D=+15.95+7.78\sin(1.2\,m+49.8)$
4	Montreal, Canada.	45 30.5	73 34.6	$D=+11.88+4.17\sin(1.5\,m-18.5)$ $+0.36\sin(4.9\,m+19)$
5	Eastport, Me.	44 54.4	66 59.2	$D=+15.18+3.79\sin(1.25\,m+31.1)$*
6	Bangor, Me.	44 48.2	68 46.9	$D=+13.86+3.55\sin(1.30\,m+8.6)$
7	Halifax, Nova Scotia.	44 39.6	63 35.3	$D=+16.18+4.53\sin(1.0\,m+46.1)$*
8	Burlington, Vt.	44 28.5	73 12.0	$D=+10.81+3.65\sin(1.30\,m-20.5)$ $+0.18\sin(7.0\,m+132)$
9	Hanover, N. H.	43 42.3	72 17.1	$D=+9.80+4.02\sin(1.4\,m-14.1)$*
10	Portland, Me.	43 38.8	70 16.6	$D=+11.40+3.28\sin(1.30\,m+2.7)$
11	Rutland, Vt.	43 36.5	72 55.5	$D=+10.03+3.82\sin(1.5\,m-24.3)$
12	Portsmouth, N. H.	43 04.3	70 42.5	$D=+10.71+3.36\sin(1.44\,m-7.4)$
13	Chesterfield, N. H.	42 53.5	72 24	$D=+9.60+3.84\sin(1.35\,m-16.1)$*
14	Newburyport, Mass.	42 48.9	70 49.2	$D=+10.07+3.02\sin(1.35\,m-1.0)$
15	Williamstown, Mass.	42 42.8	73 13.4	$D=+8.84+3.13\sin(1.4\,m-14.0)$*
16	Albany, N. Y.	42 39.2	73 45.8	$D=+8.17+3.02\sin(1.44\,m-8.3)$
17	Salem, Mass.	42 31.9	70 52.5	$D=+9.98+3.85\sin(1.4\,m-5.1)$*
18	Oxford, N. Y.	42 26.5	75 40.5	$D=+6.19+3.24\sin(1.35\,m-18.9)$
19	Cambridge, Mass.	42 22.9	71 07.7	$D=+9.54+2.69\sin(1.30\,m+7.0)$ $+0.18\sin(3.2\,m+44)$
20	Boston, Mass.	42 21.5	71 03.9	$D=+9.48+2.94\sin(1.3\,m+3.7)$
21	Provincetown, Mass.	42 03.1	70 11.3	$D=+9.67+3.04\sin(1.3\,m+11.0)$*
22	Providence, R. I.	41 50.2	71 23.8	$D=+9.10+2.99\sin(1.45\,m-3.4)$ $+0.26\sin(\ 7\ m+84)$
23	Hartford, Conn.	41 45.9	72 40.4	$D=+8.06+2.90\sin(1.25\,m-26.4)$
24	New Haven, Conn.	41 18.5	72 55.7	$D=+7.78+3.11\sin(1.40\,m-22.1)$
25	Nantucket, Mass.	41 17.0	70 06.0	$D=+8.61+2.83\sin(1.35\,m+19.7)$
26	Cold Spring Harbor, Long Island N. Y.	40 52	73 28	$D=+7.19+2.52\sin(1.35\,m-11.4)$
27	New York City, N. Y.	40 42.7	74 00.4	$D=+7.04+2.77\sin(1.30\,m-18.1)$ $+0.14\sin(6.3\,m+64)$
28	Bethlehem, Pa.	40 36.4	75 22.9	$D=+5.40+3.13\sin(1.55\,m-38.3)$
29	Huntingdon, Pa.	40 31	78 02	$D=+3.76+2.93\sin(1.48\,m-35.2)$

* A rough expression.

Results for Group I—Continued.

No.	Name of station and State.	Latitude.	West longitude.	The magnetic declination expressed as a function of time.
		° ′	° ′	° ° °
30	New Brunswick, N. J.	40 29.9	74 26.8	$D=+5.11+2.94 \sin(1.30\,m+4.2)$
31	Jamesburg, N. J.	40 21	74 27	$D=+6.03+2.94 \sin(1.40\,m-22.4)$
32	Harrisburg, Pa.	40 15.9	76 52.9	$D=+2.93+2.98 \sin(1.50\,m+0.2)$
33	Hatborough, Pa.	40 12	75 07	$D=+5.17+3.16 \sin(1.54\,m-16.7)$ $+0.22 \sin(4.1\,m+157)$
34	Philadelphia, Pa.	39 56.9	75 09.0	$D=+5.36+3.17 \sin(1.50\,m-26.1)$ $+0.19 \sin(4.0\,m+146)$
35	Chambersburg, Pa.	39 55	77 40	$D=+2.79+3.10 \sin(1.55\,m-30.6)$ $+0.20 \sin(4.6\,m+124)$
36	Baltimore, Md.	39 17.8	76 37.0	$D=+3.20+2.57 \sin(1.45\,m-21.2)$
37	Washington, D. C.	38 53.3	77 00.6	$D=+2.73+2.57 \sin(1.45\,m-21.6)$ $+0.14 \sin(12\,m+27)$
38	Cape Henlopen, Del.	38 46.7	75 05.0	$D=+4.01+3.22 \sin(1.35\,m-25.2)$
39	Williamsburg, Va.	37 16.2	76 42.4	$D=+2.33+2.56 \sin(1.5\,m-38.1)$
40	Cape Henry, Va.	36 55.6	76 00.4	$D=+2.42+2.25 \sin(1.47\,m-30.6)$
41	New Berne, N. C.	35 06	77 02	$D=+0.63+2.56 \sin(1.45\,m-18.2)$*
42	Milledgeville, Ga.	33 04.2	83 12	$D=-3.10+2.53 \sin(1.40\,m-61.9)$*.
43	Charleston, S. C.	32 46.6	79 55.8	$D=-1.82+2.75 \sin(1.40\,m-12.1)$*
44	Savannah, Ga.	32 04.9	81 05.5	$D=-2.13+2.55 \sin(1.40\,m-40.5)$*
45	Paris, France.	48 50.2	2 20.2 E.	$D=+6^\circ.479+16^\circ.002 \sin(0.765\,m+118^\circ 46'.5)$ $+[0.85-0.35 \sin(0.69\,n)] \sin[(4.04+0.0054\,n$ $+.000035\,n^2)n]$†
46	St. George's Town, Bermuda.	32 23	64 42	$D=+6.95+0.0145\,m+0.00056\,m^2$*
47	Rio de Janeiro, Brazil.	—22 54.8	43 09.5	$D=+2.19+9.91 \sin(0.80\,m-10.4)$*

* A rough expression.

† The secular variation observed at Paris is illustrated on accompanying illustration No. 21. It is introduced for the purpose of showing the extremely systematic character of this variation. In the upper half of the diagram the dots indicate the observations, and the smooth curve represents the declination according to a constant and the first periodic term $D=+6^\circ.479+16^\circ.002 \sin(0.765\,m+118^\circ 46'.5)$. At this station the phenomenon of secular variation has now been followed up for about 349 years, in which interval it exhibited two well marked extremes, viz, about the year 1581 a maximum eastern position, and about the year 1812 a maximum western position; the interval between these two consecutive elongations is 231 years, which may be regarded approximately as the time of half a period; in the formula the numerical value of a implies 470 years for the period. The secondary wave superposed upon the primary is shown in the lower half of the diagram; it has two characteristics, viz, a variability in the parameter, that is a diminution in the size of the wave since about 1540, with a possible increase now, and secondly a variability in the length of the period, which was nearly constant in the second half of the sixteenth and throughout the seventeenth centuries, but afterwards diminished rapidly. Both variations, if real, are undoubtedly periodic, though from want of sufficient data our tabular values are *limited* in time. It appeared to me doubtful whether one or two secondary waves lie between 1740 and 1870, and since the above diminution of the period hinges upon this question, two analytical expressions were presented in a preceding edition of this paper, one showing one crest, the other two crests within the interval. The latter expression is here given the preference in consequence of its better representing the latest observations. The factor (4.04, etc.) of n, where $n=t-1700$ corresponds to a length of period of about 90 years, which at present has diminished to about 57 years. These variations necessarily complicate the formula. The law, however, may be studied *at* Paris to better advantage. The station was only introduced here with the object of prominently showing the stately secular swing of the needle, and to facilitate the connection of its phases with those noted in North America.

GROUP I.—*Comparison of observed and computed Magnetic Declinations.*

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1.—SAINT JOHN'S, NEWFOUNDLAND.			
	°	°	°
1630.0	+15.00	+20.04	−5.04
1700.0	15.00	13.08	+1.92
1750.0	17.75	16.05	+1.70
1787.5	16.00	21.60	−5.60
1833.5	26.50	28.34	−1.84
1844.8	29.60	29.47	+ .13
1857.5	31.35	30.36	+ .99
1862.7	31.33	30.59	+ .74
1863.7	31.30	30.62	+ .68
1864.4	31.00	30.65	+ .35
1866.5	30.92	30.71	+ .21
1881.6	+30.52	+30.77	− .25
2.—QUEBEC, CANADA.			
1642.5	+16.00	+17.00	−1.00
1686.5	15.50	17.33	−1.83
1700.0	16.25	16.49	− .24
1750.0	12.50	12.14	+ .36
1785.5	12.58	12.24	+ .34
1789.5	11.75	12.22	− .47
1791.5	13.00	12.20	+ .80
1792.3	12.42	12.20	+ .22
1793.6	12.54	12.17	+ .37
1805.3	11.58	12.08	− .50
1810.5	11.62	12.08	− .46
1811.5	12.25	12.09	+ .16
1814.5	11.83	12.14	− .31
1820.8	12.54	12.33	+ .21
1821.7	12.90	12.36	+ .54
1822.2	13.00	12.39	+ .61
1823.6	13.00	12.45	+ .55
1824.2	12.67	12.49	+ .18
1831.7	13.40	12.99	+ .41
1832.4	13.00	13.05	− .05
1833.5	12.75	13.14	− .39
1834.4	13.31	13.22	+ .09
1835.9	13.17	13.36	− .19
1839.3	13.37	13.70	− .33
1840.5	13.71	13.81	− .10
1842.7	14.02	14.07	− .05
1846.5	14.53	14.49	+ .04
1847.7	+14.64	+14.63	+ .01
QUEBEC, CANADA—continued.			
	°	°	°
1848.5	+14.58	+14.72	− .14
1849.4	15.37	14.84	+ .53
1850.3	15.25	14.93	+ .32
1851.7	15.00	15.10	− .10
1853.1	15.50	15.26	+ .24
1858.8	15.57	15.89	− .32
1859.5	16.28	15.97	+ .31
1860.8	16.47	16.09	+ .38
1865.5	16.67	16.54	+ .13
1879.7	+17.23	+17.38	− .15
3.—CHARLOTTETOWN, PRINCE EDWARD ISLAND.			
1833.0	+19.50	+19.76	− .26
1842.4	21.05	21.02	+ .03
1857.4	23.04	22.60	+ .44
1858.4	22.90	22.68	+ .22
1859.4	22.85	22.76	+ .09
1860.4	22.83	22.84	− .01
1861.4	22.75	22.91	− .16
1862.4	23.32	22.98	+ .34
1883.7	+23.43	+23.73	− .30
4.—MONTREAL, CANADA.			
1700.0	+14.75	+15.63	− .88
1749.5	10.63	10.76	− .13
1785.5	8.40	8.45	− .05
1793.6	8.25	8.16	+ .09
1814.5	7.75	7.77	− .02
1834.5	8.00	8.80	− .80
1835.5	9.83	8.90	+ .93
1842.6	8.97	9.70	− .73
1859.5	12.35	11.90	+ .45
1879.7	+13.67	+13.79	− .12
5.—EASTPORT, ME.			
1608.0	+17.53	+18.95	−1.42
1700.0	13.30	13.64	− .34
1750.0	11.40	11.38	+ .02
1775.5	+12.67	+11.81	+ .86
EASTPORT, ME.—continued.			
	°	°	°
1797.5	+12.32	+13.01	− .69
1833.0	14.50	15.81	−1.31
1860.8	17.95	17.82	+ .13
1861.5	17.99	17.86	+ .13
1862.5	18.01	17.92	+ .09
1863.5	18.04	17.98	+ .06
1864.3	18.06	18.02	+ .04
1865.6	18.10	18.09	+ .01
1873.7	18.93	18.46	+ .47
1879.7	19.13	18.68	+ .45
1887.7	+18.59	+18.87	− .28
6.—BANGOR, ME.			
1805.5	+11.25	+11.17	+ .08
1837.5	13.07	13.39	− .32
1840.5	13.37	13.63	− .26
1844.6	14.48	13.96	+ .52
1857.8	15.33	15.00	+ .33
1879.6	+16.49	+16.46	+ .03
7.—HALIFAX, NOVA SCOTIA.			
1608.0	+16.25	+17.42	−1.17
1630.0	14.00	15.70	−1.70
1700.0	12.75	11.80	+ .95
1750.0	12.00	12.52	− .52
1756.5	12.83	12.85	− .02
1775.5	13.58	14.02	− .44
1798.5	16.50	15.75	+ .75
1818.5	17.47	17.32	+ .15
1821.6	17.60	17.56	+ .04
1833.0	17.50	18.38	− .88
1852.7	18.77	19.59	− .82
1853.2	18.85	19.62	− .77
1860.5	19.92	19.96	− .04
1866.3	21.09	20.19	+ .90
1873.4	21.58	20.42	+1.16
1879.7	+20.72	+20.57	+ .15
8.—BURLINGTON, VT.			
1793.5	+ 7.63	+ 7.35	+ .28
1805.5	+ 6.20	+ 7.22	−1.02

GROUP I.—*Comparison of observed and computed Magnetic Declinations*—Continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
BURLINGTON, VT.—continued.			
	°	°	°
1818.5	+ 7.50	+ 7.43	+ .07
1822.5	7.70	7.62	+ .08
1826.5	7.60	7.88	— .28
1830.5	8.17	8.18	— .01
1831.5	8.25	8.26	— .01
1832.5	8.42	8.34	+ .08
1834.5	8.83	8.50	+ .33
1837.5	8.75	8.75	.00
1845.5	9.37	9.37	.00
1855.7	9.95	10.01	— .06
1870.9	10.95	11.12	— .17
1873.8	+11.32	+11.31	+ .01
9.—HANOVER, N. H.			
1765.5	+ 7.00	+ 6.83	+ .17
1810.5	4.25	6.04	—1.79
1839.5	9.25	7.87	+1.38
1855.7	10.45	9.37	+1.08
1873.7	10.83	11.11	— .28
1876.6	11.09	11.38	— .29
1879.8	+11.64	+11.66	— .02
10.—PORTLAND, ME.			
1700.0	+12.10	+12.16	— .06
1750.0	9.20	8.85	+ .35
1763.5	7.75	8.37	— .62
1775.5	8.50	8.19	+ .31
1845.4	11.47	11.27	+ .20
1851.6	11.69	11.74	— .05
1859.5	12.33	12.31	+ .02
1863.5	12.47	12.59	— .12
1864.8	12.73	12.69	+ .04
1865.5	12.71	12.74	— .03
1866.1	12.72	12.77	— .05
1873.7	12.89	13.27	— .38
1887.8	+13.85	+14.04	— .19
11.—RUTLAND, VT.			
1789.3	+ 7.05	+ 6.58	+ .47
1810.4	+ 6.07	+ 6.23	— .16

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
RUTLAND, VT.—continued.			
	°	°	°
1811.7	+ 6.02	+ 6.25	— .23
1859.6	9.82	9.37	+ .45
1873.8	10.67	10.79	— .12
1879.8	+11.15	+11.36	— .21
12.—PORTSMOUTH, N. H.			
1771.5	+ 7.77	+ 7.81	— .04
1775.5	7.75	7.66	+ .09
1833.0	8.75	8.94	— .19
1845.0	9.78	9.86	— .08
1850.7	10.50	10.33	+ .17
1859.5	11.25	11.08	+ .17
1879.6	+12.52	+12.65	— .13
13.—CHESTERFIELD, N. H.			
1812.5	+ 6.43	+ 6.07	+ .36
1813.5	6.42	6.11	+ .31
1814.5	6.28	6.15	+ .13
1815.5	6.12	6.19	— .07
1816.5	6.05	6.23	— .18
1817.5	6.04	6.27	— .23
1818.5	6.00	6.32	— .32
1819.5	6.05	6.37	— .32
1820.5	6.00	6.42	— .42
1821.5	6.12	6.47	— .35
1822.5	6.20	6.52	— .32
1823.5	6.50	6.58	— .08
1824.5	6.67	6.64	+ .03
1825.5	6.58	6.70	— .12
1826.5	6.58	6.76	— .18
1827.5	6.75	6.82	— .07
1828.5	6.87	6.88	— .01
1829.5	7.00	6.94	+ .06
1830.5	7.10	7.01	+ .09
1831.5	7.17	7.08	+ .09
1832.5	7.25	7.15	+ .10
1833.5	7.50	7.22	+ .28
1834.5	7.58	7.29	+ .29
1835.5	7.67	7.36	+ .31
1836.5	7.75	7.44	+ .31
1837.5	8.09	7.52	+ .57
1874.7	+10.44	+10.74	— .30

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
14.—NEWBURYPORT, MASS.			
	°	°	°
1750.0	+ 8.23	+ 7.97	+ .26
1775.5	6.75	7.11	— .36
1781.5	7.30	7.06	+ .24
1833.0	8.50	8.84	— .34
1850.7	10.09	10.07	+ .02
1859.5	10.97	10.69	+ .28
1887.8	+12.20	+12.38	— .18
15.—WILLIAMSTOWN, MASS.			
1750.0	+ 7.54	+ 7.47	+ .07
1786.5	5.87	5.79	+ .08
1833.5	6.25	6.95	— .70
1837.5	7.75	7.21	+ .54
1876.6	10.52	10.07	+ .45
1886.6	+10.35	+10.73	— .38
16.—ALBANY, N. Y.			
1817.8	+ 5.73	+ 5.71	+ .02
1818.6	5.75	5.74	+ .01
1825.3	6.00	6.08	— .08
1828.6	6.27	6.26	+ .01
1830.5	6.30	6.38	— .08
1831.6	6.54	6.45	+ .09
1834.8	6.67	6.65	+ .02
1836.8	6.78	6.78	.00
1847.9	7.58	7.58	.00
1855.7	7.91	8.17	— .26
1856.7	8.58	8.24	+ .34
1858.4	8.28	8.37	— .09
1879.6	+ 9.86	+ 9.87	— .01
17.—SALEM, MASS.			
1750.0	+ 7.89	+ 7.78	+ .11
1781.6	6.90	6.20	+ .70
1805.8	5.95	6.44	— .49
1808.5	5.33	6.54	—1.21
1810.8	5.94	6.65	— .71
1833.0	8.50	8.12	+ .38
1849.6	10.24	9.60	+ .64
1855.6	10.83	10.16	+ .67
1877.5	11.50	12.10	— .60
1887.8	+12.64	+12.83	— .19

Group I.—*Comparison of observed and computed Magnetic Declinations*—Continued.

18.—OXFORD, N. Y.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1794.0	+ 3.00	+ 2.96	+ .04
1817.5	3.00	3.31	— .31
1828.5	4.50	3.79	+ .71
1834.8	3.87	4.13	— .26
1836.8	4.15	4.26	— .11
1837.5	4.50	4.30	+ .20
1838.5	4.45	4.36	+ .09
1849.9	5.18	5.14	+ .04
1857.3	5.73	5.68	+ .05
1858.1	5.78	5.74	+ .04
1859.0	5.83	5.81	+ .02
1873.9	6.87	6.94	— .07
1874.4	6.93	6.97	— .04
1885.7	+ 7.72	+ 7.77	— .05

19.—CAMBRIDGE, MASS.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1708.5	+ 9.00	+ 9.26	— .26
1742.5	8.00	7.66	+ .34
1757.5	7.33	7.24	+ .09
1761.5	7.23	7.13	+ .10
1763.5	7.00	7.09	— .09
1780.5	7.03	6.86	+ .17
1782.5	6.75	6.85	— .10
1783.5	6.87	6.86	+ .01
1788.5	6.63	6.89	— .26
1810.5	7.50	7.48	+ .02
1835.5	8.85	8.98	— .13
1837.5	9.15	9.11	+ .04
1840.4	9.30	9.32	— .02
1842.2	9.57	9.45	+ .12
1844.5	9.65	9.61	+ .04
1845.4	9.53	9.68	— .15
1850.6	9.50	10.03	— .53
1852.5	10.13	10.16	— .03
1854.5	10.21	10.29	— .08
1055.4	10.91	10.35	+ .56
1856.5	10.47	10.42	+ .05
1859.2	10.80	10.59	+ .21
1867.5	10.70	11.05	— .35
1879.6	+11.77	+11.58	+ .19

20.—BOSTON, MASS.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1700.0	+10.00	+10.06	— .06
1708.5	+ 9.00	+ 9.49	— .49

BOSTON, MASS.—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1741.5	+ 7.50	+ 7.49	+ .01
1776.0	7.67	6.54	+1.13
1782.5	7.00	6.55	+ .45
1793.5	6.50	6.72	— .22
1807.5	6.08	7.18	—1.10
1833.0	8.00	8.55	— .55
1839.5	9.10	8.97	+ .13
1846.7	9.52	9.45	+ .07
1855.6	10.23	10.04	+ .19
1872.8	11.25	11.09	+ .16
1877.5	+11.60	+11.35	+ .25

21.—PROVINCETOWN, MASS.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1630.0	+12.20	+12.71	— .51
1700.0	9.50	9.88	— .38
1750.0	7.70	7.01	+ .69
1776.5	6.50	6.65	— .15
1833.0	8.25	9.09	— .84
1835.7	9.33	9 13	+ .20
1860.7	+11.39	+10 87	+ .52

22.—PROVIDENCE, R. I.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1717.5	+ 9.60	+ 9.68	— .08
1769.5	6.50	6.28	+ .22
1815.5	6.50	6.60	— .10
1819.5	6.62	6.69	— .07
1835.5	7.57	7.79	— .22
1840.5	8.42	8.30	+ .12
1841.5	8.52	8.40	+ .12
1842.5	8.65	8.50	+ .15
1843.5	8.77	8.60	+ .17
1855.6	9.52	9.56	— .04
1884.5	11.13	11.13	.00
1885.3	+11.16	+11.19	— .03

23.—HARTFORD, CONN.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1750.0	+ 6.78	+ 6.67	+ .11
1786.5	5.42	5.28	+ .14
1810.5	4.77	5.25	— .48
1824.5	5.75	5 60	+ .15
1829.0	+ 6.05	+ 5.76	+ .29

HARTFORD, CONN.—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1859.6	+ 7.29	+ 7.34	— .05
1867.6	7.82	7.84	— .02
1879.6	+ 8.57	+ 8.59	— .02

24.—NEW HAVEN, CONN.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1750.0	+ 6.24	+ 6.82	— .58
1761.5	5.78	6.04	— .26
1775.5	5.42	5.28	+ .14
1780.5	5.25	5.07	+ .18
1811.5	5.17	4.76	+ .41
1819.8	4.42	4.97	— .55
1828.5	5.28	5.32	— .04
1835.3	5.68	5.67	+ .01
1836.5	5.92	5.74	+ .18
1837.9	5.83	5.82	+ .01
1840.5	6.17	5.98	+ .19
1844.6	5.75	6.24	— .49
1845.7	6.29	6.32	— .03
1848.6	6.58	6.51	+ .07
1855.6	7.05	7.01	+ .04
1872.5	8.46	8.29	+ .17
1878.5	8.69	8.73	— .04
1884.5	8.93	9.15	— .22
1885.2	+ 9.00	+ 9.20	— .20

25.—NANTUCKET, MASS.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1700.0	+ 8.42	+ 9.06	— .64
1750.0	6.90	6.46	+ .44
1775.5	6.50	6.16	+ .34
1833.0	7.50	8.52	—1.02
1834.5	8.45	8.62	— .17
1839.0	9.04	8.89	+ .15
1842.7	9.15	9.12	+ .03
1843.7	9.17	9.18	— .01
1846.6	9.23	9.37	— .14
1855.6	9.97	9.90	+ .07
1867.4	10.33	10.52	— .19
1879.6	11.46	11.03	+ .43
1883.4	+11.43	+11.15	+ .28

26.—COLD SPRING HARBOR, N. Y.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1750.0	+ 5.70	+ 5.80	— .10
1771.4	+ 5.12	+ 4.96	+ .16

GROUP I.—*Comparison of observed and computed Magnetic Declinations*—Continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
COLD SPRING HARBOR, N. Y.—continued.			
	°	°	°
1818.4	+ 4.87	+ 5.15	— .28
1844.7	6.52	6.39	+ .13
1865.0	7.78	7.58	+ .20
1886.5	+ 8.57	+ 8.74	— .17
27.—NEW YORK, N. Y.			
1609.7	+ 8.00	+ 8.40	— .40
1630.0	11.50	9.34	+2.16
1684.5	8.75	9.26	— .51
1686.5	9.00	9.19	— .19
1691.5	8.75	8.97	— .22
1700.0	8.33	8.55	— .22
1714.5	8.75	7.73	+1.02
1724.0	7.33	7.13	+ .20
1750.0	5.92	5.58	+ .34
1755.5	5.00	5.30	— .30
1789.5	4.33	4.29	+ .04
1824.5	4.67	4.88	— .21
1834.5	4.83	5.33	— .50
1837.5	5.67	5.48	+ .19
1840.6	5.45	5.65	— .20
1841.5	6.10	5.70	+ .40
1842.6	5.91	5.75	+ .16
1844.6	6.22	5.87	+ .35
1845.6	6.42	5.93	+ .49
1846.3	5.57	5.96	— .39
1847.8	5.68	6.05	— .37
1855.6	6.72	6.52	+ .20
1860.7	6.73	6.84	— .11
1873.8	7.48	7.65	— .17
1874.6	7.38	7.71	— .33
1879.5	7.87	8.00	— .13
1885.7	+ 8.21	8.35	— .14
28.—BETHLEHEM, PA.			
1757.5	+ 6.50	+ 5.49	+1.01
1784.5	2.88	3.38	— .50
1799.5	1.87	2.60	— .73
1841.6	3.43	2.96	+ .47
1851.5	3.83	3.56	+ .27

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
BETHLEHEM, PA.—continued.			
	°	°	°
1874.5	+ 5.32	+ 5.38	— .06
1878.2	5.62	5.69	— .07
1881.2	5.87	5.95	— .08
1882.7	6.08	6.07	+ .01
1884.0	+ 6.10	+ 6.18	— .08
29.—HUNTINGDON, PA.			
1750.0	+ 4.25	+ 3.92	+ .33
1794.0	0.85	1.18	— .33
1840.6	1.87	1.55	+ .32
1849.3	2.18	2.03	+ .15
1852.3	2.27	2.22	+ .05
1858.7	2.57	2.65	— .08
1860.3	2.68	2.76	— .08
1874.6	3.57	3.82	— .25
1879.6	4.12	4.20	— .08
1880.7	4.25	4.28	— .03
1881.5	4.39	4.34	+ .05
1883.3	4.56	4.47	+ .09
1884.4	4.62	4.55	+ .07
1886.0	+ 4.63	+ 4.67	— .04
30.—NEW BRUNSWICK, N. J.			
1800.5	+ 2.40	+ 2.56	— .16
1804.5	2.50	2.70	— .20
1811.5	3.32	3.00	+ .32
1814.6	3.12	3.15	— .03
1815.9	3.22	3.22	.00
1836.6	4.67	4.44	+ .23
1838.5	4.75	4.56	+ .19
1848.6	5.17	5.23	— .06
1850.8	5.38	5.38	.00
863.0	6.15	6.17	— .02
1864.5	6.17	6.26	— .09
1866.5	6.00	6.38	— .38
1870.5	6.40	6.62	— .22
1880.5	7.25	7.14	+ .11
1884.5	7.50	7.33	+ .17
1886.5	7.50	7.41	+ .09
1887.7	+ 7.55	+ 7.46	+ .09

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
31.—JAMESBURG AND VICINITY, N. J.			
	°	°	°
1761.5	+ 4.55	+ 4.40	+ .15
1795.5	3.18	3.13	+ .05
1799.5	2.72	3.10	— .38
1815.5	3.20	3.23	— .03
1826.5	3.83	3.62	+ .21
1829.5	3.87	3.75	+ .12
1887.5	+ 7.42	+ 7.51	— .09
32.—HARRISBURG, PA.			
1795.6	— 0.43	— 0.02	— .41
1840.5	+ 3.21	+ 2.21	+1.00
1843.5	2.58	2.44	+ .14
1854.8	3.01	3.31	— .30
1857.4	3.32	3.51	— .19
1861.0	3.50	3.79	— .29
1862.6	3.74	3.90	— .16
1874.8	4.85	4.74	+ .11
1876.9	5.17	4.86	+ .31
1877.7	4.89	4.91	— .02
1881.4	5.28	5.12	+ .16
1885.6	5.36	5.33	+ .03
1889.1	+ 5.52	5.48	+ .04
33.—HATBOROUGH, PA.			
1680.5	+ 8.47	+ 8.31	+ .16
1690.5	8.25	8.16	+ .09
1700.5	7.92	7.86	+ .06
1710.5	7.47	7.45	+ .02
1720.5	7.00	6.96	+ .04
1730.5	6.42	6.38	+ .04
1740.5	5.58	5.66	— .08
1750.5	4.92	4.83	+ .09
1760.5	4.00	3.93	+ .07
1770.5	2.92	3.07	— .15
1780.5	2.08	2.38	— .30
1790.5	1.83	1.95	— .12
1800.5	1.92	1.84	+ .08
1810.5	2.00	2.05	— .05
1820.5	2.45	2.50	— .05
1830.5	3.00	3.08	— .08
1840.5	3.83	3.73	+ .10
1850.5	+ 4.42	+ 4.39	+ .03

GROUP I.—*Comparison of observed and computed Magnetic Declinations*—Continued.

34.—PHILADELPHIA, PA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1701.5	+ 8.50	+ 8.13	+ .37
1710.5	8.50	7.81	+ .69
1750.5	5.75	5.28	+ .47
1793.5	1.50	2.22	— .72
1802.5	1.50	2.14	— .64
1804.5	2.08	2.09	— .01
1813.5	2.43	2.23	+ .20
1837.5	3.87	3.31	+ .56
1840.5	3.62	3.49	+ .13
1841.7	3.90	3.57	+ .33
1846.4	3.85	3.85	.00
1855.7	4.53	4.45	+ .08
1862.6	5.00	4.90	+ .10
1872.8	5.46	5.64	— .18
1877.7	6.04	6.03	+ .01
1884.7	+ 6.36	+ 6.57	— .21

35.—CHAMBERSBURG, PA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1736.8	+ 4.25	+ 4.03	+ .22
1744.7	3.67	3.53	+ .14
1746.2	3.32	3.43	— .11
1754.5	3.27	2.86	+ .41
1768.6	1.50	1.76	— .26
1770.3	1.50	1.62	— .12
1786.2	+ 0.25	0.36	— .11
1787.2	— 0.25	+ 0.29	— .54
1794.5	0.50	— 0.13	— .37
1808.5	0.71	0.48	— .23
1816.9	0.50	0.38	— .12
1818.4	0.37	0.33	— .04
1822.9	— 0.25	0.17	— .08
1825.9	0.00	— 0.04	+ .04
1830.8	+ 0.25	+ 0.22	+ .03
1836.2	0.45	0.52	— .07
1840.6	0.99	0.79	+ .20
1850.3	1.50	1.39	+ .11
1852.3	1.70	1.52	+ .18
1859.8	2.20	2.01	+ .19
1863.2	2.25	2.23	+ .02
1864.2	2.32	2.30	+ .02
1865.4	2.40	2.38	+ .02
1866.1	+ 2.42	+ 2.43	— .01

CHAMBERSBURG, PA.—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1867.8	+ 2.58	+ 2.54	+ .04
1869.4	2.67	2.65	+ .02
1871.4	2.92	2.79	+ .13
1873.3	3.00	2.93	+ .07
1876.5	3.21	3.17	+ .04
1877.4	3.33	3.24	+ .09
1878.3	3.35	3.31	+ .04
1879.3	3.47	3.38	+ .09
1880.3	3.53	3.47	+ .06
1881.3	3.60	3.54	+ .06
1882.3	3.72	3.63	+ .09
1883.6	3.78	3.72	+ .06
1884.3	3.82	3.78	+ .04
1885.4	3.88	3.87	+ .01
1886.4	3.88	3.95	— .07
1887.1	4.00	4.01	— .01
1888.5	4.04	4.13	— .09
1889.1	+ 4.09	+ 4.17	— .08

36.—BALTIMORE, MD.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1679.0	+ 5.25	+ 5.77	— .52
1683.5	6.25	5.75	+ .50
1703.5	5.12	5.27	— .15
1720.5	4.21	4.45	— .24
1729.2	4.02	3.93	+ .09
1754.5	2.28	2.31	— .03
1756.9	2.88	2.16	+ .72
1771.0	1.11	1.41	— .30
1776.1	1.75	1.19	+ .56
1780.5	0.77	1.02	— .25
1787.5	0.37	0.82	— .45
1808.5	0.21	0.66	— .45
1840.7	2.27	1.76	+ .51
1847.3	2.31	2.11	+ .20
1856.7	2.49	2.69	— .20
1875.5	3.74	3.90	— .16
1877.8	4.18	4.04	+ .14
1885.6	+ 4.49	+ 4.50	— .01

37.—WASHINGTON, D. C.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1750.0	+ 2.50	+ 2.14	+ .36
1792.5	— 0.24	+ 0.25	— .49

WASHINGTON, D. C.—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1809.9	+ 0.87	+ 0.06	+ .81
1841.0	1.34	1.13	+ .21
1842.0	1.40	1.19	+ .21
1855.5	2.40	2.27	+ .13
1856.6	2.36	2.33	+ .03
1857.2	2.41	2.36	+ .05
1860.7	2.44	2.52	— .08
1862.7	2.66	2.59	+ .07
1863.6	2.70	2.63	+ .07
1866.8	2.74	2.74	.00
1867.5	2.80	2.78	+ .02
1868.5	2.85	2.83	+ .02
1869.3	2.88	2.87	+ .01
1870.5	2.89	2.95	— .06
1871.5	2.95	3.02	— .07
1872.5	3.00	3.10	— .10
1873.5	3.00	3.18	— .18
1874.5	3.11	3.26	— .15
1875.5	3.26	3.35	— .09
1876.3*	3.31	3.42	— .11
1877.5	3.66	3.54	+ .12
1878.6	3.75	3.62	+ .13
1879.4	3.84	3.69	+ .15
1880.3	3.92	3.77	+ .15
1882.5	3.93	3.96	— .03
1883.5	4.00	4.03	— .03
1884.3	4.03	4.08	— .05
1885.5	4.19	4.15	+ .04
1886.5	4.15	4.20	— .05
1887.6	4.08	4.25	— .17
1888.5	4.15	4.28	— .13
1889.7	+ 4.25	+ 4.32	— .07

38.—CAPE HENLOPEN, DEL.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1700.0	+ 6.00	+ 6.39	— .39
1750.0	3.50	2.92	+ .58
1795.5	0.92	0.83	+ .09
1833.0	1.25	1.61	— .36
1843.8	2.43	2.23	+ .20
1846.5	2.75	2.40	+ .35
1856.6	3.07	3.11	— .04
1885.6	+ 4.99	+ 5.26	— .27

* Change of station between 1876 and 1877.

GROUP I.—*Comparison of observed and computed Magnetic Declinations*—Continued.

39.—WILLIAMSBURG, VA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1694.5	+ 5.00	+ 4.67	+ .33
1750.0	1.93	2.29	— .36
1780.5	+ 0.83	+ 0.49	+ .34
1809.5	— 0.55	— 0.28	— .27
1840.0	+ 0.75	+ 0.38	+ .37
1874.9	2.20	2.43	— .23
1887.3	+ 3.05	+ 3.20	— .15

40.—CAPE HENRY, VA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1700.0	+ 4.00	+ 4.55	— .55
1728.2	3.33	3.60	— .27
1732.5	4.53	3.31	+1.22
1750.0	1.78	2.33	— .55
1809.5	0.00	0.17	— .17
1832.4	0.75	0.54	+ .21
1856.7	1.47	1.62	— .15
1874.9	2.66	2.66	.00
1879.4	2.70	2.91	— .21
1881.4	3.27	3.02	+ .25
1883.5	3.37	3.14	+ .23
1884.5	3.18	3.19	— .01
1887.3	+ 3.34	+ 3.34	.00

41.—NEW BERNE, N. C.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1750.0	+ 0.29	— 0.11	+ .40
1796.5	— 2.67	1.92	— .75
1806.5	2.00	1.90	— .10
1809.5	— 1.75	1.86	+ .11
1840.0	0.00	— 0.75	+ .75
1875.0	+ 1.34	+ 1.42	— .08
1887.2	+ 1.91	+ 2.13	— .22

42.—MILLEDGEVILLE, GA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1750.0	— 2.05	— 2.16	+ .11
1805.5	5.50	5.18	— .32
1835.5	4.67	5.61	+ .94
1838.5	5.85	5.57	— .28
1875.5	4.24	4.22	— .02
1887.2	— 3.61	— 3.53	— .08

43.—CHARLESTON, S. C.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1700.0	— 0.50	+ 0.06	— .56
1750.0	1.65	— 3.10	+1.45
1775.5	3.80	4.28	+ .48
1784.1	5.25	4.48	— .77
1785.8	5.75	4.51	—1.24
1825.0	3.75	3.83	+ .08
1833.0	4.00	3.42	— .58
1837.5	2.90	3.17	+ .27
1840.5	2.73	2.99	+ .26
1841.4	2.40	2.93	+ .53
1847.8	2.25	2.53	+ .28
1849.3	2.28	2.43	+ .15
1874.4	0.97	0.76	— .21
1880.1	0.43	0.42	— .01
1886.0	— 0.24	— 0.08	— .16

44.—SAVANNAH, GA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1750.0	— 2.21	— 2.13	— .08
1817.5	4.00	4.67	+ .67
1833.0	5.00	4.43	— .57
1838.5	5.08	4.26	— .82
1839.5	3.52	4.22	+ .70
1852.3	3.67	3.67	.00
1857.3	3.46	3.42	— .04
1874.2	2.28	2.42	+ .14
1886.0	— 1.62	— 1.69	+ .07

45.—PARIS, FRANCE.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1541.5	— 7.00	— 6.60	— .40
1550.5	8.00	7.50	— .50
1580.5	11.50	10.73	— .77
1603.5	8.75	8.76	+ .01
1610.5	8.00	7.64	— .36
1630.5	4.50	4.51	+ .01
1642.5	2.50	3.08	+ .58
1660.0	1.50	1.11	— .39
1664.5	— 0.67	0.47	— .20
1667.0	+ 0.13	— 0.08	+ .21
1670.5	1.50	+ 0.51	+ .99
1682.5	+ 3.13	+ 3.03	+ .10

PARIS, FRANCE—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1687.5	+ 4.87	+ 4.25	+ .62
1695.1	6.62	6.27	+ .35
1703.5	9.00	8.54	+ .46
1712.5	11.18	10.86	+ .32
1721.5	12.87	12.84	+ .03
1730.5	14.62	14.40	+ .22
1739.5	15.38	15.61	— .23
1748.5	16.62	16.66	— .04
1757.1	17.82	17.69	+ .13
1765.6	19.00	18.92	+ .08
1772.5	20.02	20.01	+ .01
1779.5	20.67	21.09	— .42
1784.5	21.42	21.75	— .33
1791.5	22.30	22.39	— .09
1800.0	22.23	22.64	— .41
1803.5	21.97	22.59	— .62
1805.5	22.08	22.53	— .45
1807.5	22.57	22.45	+ .12
1812.2	22.33	22.21	+ .12
1816.5	22.37	22.02	+ .35
1827.2	22.25	21.80	+ .45
1835.5	22.07	21.84	+ .23
1838.2	21.63	21.82	— .19
1842.5	21.48	21.66	— .18
1858.0	19.60	19.51	+ .09
1865.5	18.73	18.10	+ .63
1869.7	17.14	17.52	— .38
1875.5	17.35	16.94	+ .41
1879.0	16.93	16.71	+ .22
1885.5	16.20	16.01	+ .19
1886.5	16.10	15.84	+ .26
1887.0	16.03	15.76	+ .27
1888.5	+15.95	+15.46	+ .49

46.—ST. GEORGE'S TOWN, BERMUDA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1831.5	+ 6.98	+ 6.88	+ .10
1837.5	6.67	6.85	— .18
1845.8	7.02	6.90	+ .12
1846.5	6.88	6.91	— .03
1873.3	7.21	7.60	— .39
1876.5	+ 7.75	+ 7.73	+ .02

GROUP I.—*Comparison of observed and computed Magnetic Declinations*—Continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.	Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.	Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
47.—RIO DE JANEIRO, BRAZIL.				RIO DE JANEIRO—continued.				RIO DE JANEIRO—continued.			
	°	°	°		°	°	°		°	°	′
1768.5	— 7.57	— 7.41	— .16	1830.5	— 2.14	— 2.15	+ .01	1876.5	+ 4.43	+ 4.05	+ .38
1787.5	6.20	6.42	+ .22	1836.5	— 2.00	— 1.40	— .60	1882.6	+ 4.65	+ 4.88	— .23
1820.5	2.90	3.35	+ .45	1857.5	+ 1.33	+ 1.43	— .10				
1821.5	— 3.35	— 3.24	— .11	1866.0	+ 2.70	+ 2.61	+ .09				

RESULTS FOR GROUP I—Continued.

Contents of columns: The third column gives the year of first observation; the fourth, the whole number of observations used in the discussion; the fifth, the probable error of an observation or of a representation; the sixth, the year of nearest easterly digression or magnetic elongation with corresponding amount of minimum *west* declination (or maximum *east* declination); the remaining columns are explained by their headings; the annual change is given for three modern epochs. *West* declination is indicated by a *plus* sign as is also *increasing west* declination; the contrary direction is indicated by a minus sign.

Number.	Station.	Year of first observation.	Number of observations.	Probable error of an observation.	Epoch of nearest eastern elongation.	Extreme declination, minimum, when west, maximum, when east, at epoch.	Epoch of nearest western elongation.	Extreme declination, maximum, when west, minimum, when east, at epoch.	Annual change in 1885.0	1890.0	1895.0
				′		°		°	′	′	′
1	Saint John's, Newfoundland.	1630(?)	12	±31	1704	+13.0	1875	+30.8	—1.7	—2.4	—3.4
2	Quebec, Canada.	1642	38	20	1807	+12.1	1889(?)	+17.5	+0.7	0.0	—0.9
3	Charlottetown, Prince Edward Island.	1833	9	12	1734	+ 8.2	1884	+23.7	—0.3	—1.4	—2.4
4	Montreal, Canada.	1700(?)	10	31	1814	+ 7.7	----	----	+3.6	+3.3	+3.4
5	Eastport, Me.	1608	15	21	1753	+11.4	1897(?)	+19.0	+1.3	+0.8	+0.2
6	Bangor, Me.	1805	5	16	1774	+10.3	1912(?)	+17.4	+2.8	+2.4	+1.9
7	Halifax, Nova Scotia.	1608	16	33	1714	+11.6	1894(?)	+20.7	+0.7	+0.3	—0.1
8	Burlington, Vt.	1793	14	12	1810	+ 7.2	----	----	+5.8	+5.0	+3.8
9	Hanover, N. H.	1765	7	27	1796	+ 5.8	----	----	+4.8	+4.4	+3.9
10	Portland, Me.	1700(?)	13	10	1779	+ 8.1	1917(?)	+14.7	+3.0	+2.6	+2.2
11	Rutland, Vt.	1789	6	16	1806	+ 6.2	----	----	+5.3	+4.9	+4.4
12	Portsmouth, N. H.	1771	7	7	1793	+ 7.3	----	----	+3.7	+3.2	+2.7
13	Chesterfield, N. H.	1812	27	16	1795	+ 5.8	----	----	+4.6	+4.3	+3.9
14	Newburyport, Mass.	1750(?)	7	13	1784	+ 7.0	1918(?)	+13.1	+3.0	+2.6	+2.2
15	Williamstown, Mass.	1750(?)	6	31	1796	+ 5.7	----	----	+3.8	+3.4	+3.0
16	Albany, N. Y.	1817	13	6	1793	+ 5.2	----	----	+3.4	+3.0	+2.5
17	Salem, Mass.	1750(?)	10	26	1789	+ 6.1	1918(?)	+13.8	+4.1	+3.6	+3.0
18	Oxford, N. Y.	1794	14	9	1797	+ 3.0	----	----	+4.0	+3.7	+3.4
19	Cambridge, Mass.	1708	24	±11	1783	+ 6.9	----	----	+1.8	+1.5	+1.2

RESULTS FOR GROUP I—Continued.

Number.	Station.	Year of first observation.	Number of observations.	Probable error of an observation.	Epoch of nearest eastern elongation.	Extreme declination, minimum, when west, maximum, when east, at epoch.	Epoch of nearest western elongation.	Extreme declination, maximum, when west, minimum, when east, at epoch.	Annual changes in 1885.0	1890.0	1895.0
				′		°		°	′	′	′
20	Boston, Mass.	1700	13	±23	1778	+ 6.5	----	----	+2.6	+2.2	+1.9
21	Provincetown, Cape Cod, Mass.	1630(?)	7	17	1772	+ 6.6	1911(?)	+12.7	+2.3	+1.9	+1.4
22	Providence, R. I.	1717	12	7	1779	+ 6.0	----	----	+4.7	+4.4	+3.6
23	Hartford, Conn.	1750(?)	8	12	1799	+ 5.2	----	----	+3.6	+3.5	+3.3
24	New Haven, Conn.	1750(?)	19	11	1802	+ 4.7	----	----	+4.1	+3.8	+3.4
25	Nantucket, Mass.	1700(?)	13	14	1771	+ 6.1	1904(?)	+11.5	+1.6	+1.2	+0.8
26	Cold Spring Harbor, N. Y.	1750(?)	6	10	1792	+ 4.7	1925(?)	+ 9.7	+2.9	+2.6	+2.3
27	New York City, N. Y.	1609	27	18	1784	+ 4.4	----	----	+3.7	+3.8	+3.8
28	Bethlehem, Pa.	1757	10	19	1817	+ 2.3	----	----	+4.9	+4.6	+4.3
29	Huntingdon, Pa.	1794	14	7	1813	+ 0.8	----	----	+4.3	+4.1	+3.9
30	New Brunswick, N. J.	1800	17	8	1778	+ 2.2	----	----	+2.6	+2.2	+1.8
31	Jamesburg, N. J.	1761	7	10	1802	+ 3.1	----	----	+3.8	+3.6	+3.3
32	Harrisburg, Pa.	1795	13	15	1790	0.0	----	----	+2.8	+2.3	+1.8
33	Hatboro', Pa.	1680	18(?)	6	1797	+ 1.8	----	----	+5.2	+4.4	+3.3
34	Philadelphia, Pa.	1701	16	17	1802	+ 2.1	----	----	+4.7	+4.4	+4.4
35	Chambersburg, Pa.	1736	42	7	1809	— 0.5	----	----	+4.8	+4.9	+4.8
36	Baltimore, Md.	1679	18	17	1802	+ 0.6	----	----	+3.4	+3.1	+2.8
37	Washington, D. C.	1750(?)	33	6	1803	+ 0.2	1927(?)	+ 5.3	+3.2	+1.5	+1.2
38	Cape Henlopen, Del.	1609	8	19	1802	+ 0.8	----	----	+4.2	+4.0	+3.7
39	Williamsburg, Va.	1694	7	16	1811	— 0.3	----	----	+3.6	+3.4	+3.2
40	Cape Henry, Va.	1700	13	20	1810	+ 0.2	----	----	+3.2	+3.0	+2.8
41	New Berne, N. C.	1750(?)	7	24	1801	— 1.9	----	----	+3.3	+3.0	+2.6
42	Milledgeville, Ga.	1750(?)	6	18	1830	— 5.6	----	----	+3.6	+3.7	+3.7
43	Charleston, S. C.	1700	15	28	1794	— 4.6	----	----	+3.2	+2.9	+2.5
44	Savannah, Ga.	1750(?)	9	23	1815	— 4.7	----	----	+3.7	+3.6	+3.4
					At eastern elongation.		At western elongation.				
					Epoch.	Amount.	Epoch.	Amount.			
						°		°			
45	Paris, France.*	1541	45	17	1581	—10.7	1799	+22.6	—8.8†	----	----
46	Saint George's Town, Bermuda.	1831	6	11	1838	+ 6.8	----	----	+3.4	+3.6	+3.8
47	Rio de Janeiro, Brazil.	1768	10	±14	----	----	----	----	+7.9	+7.7	+7.5

* The maximum west declination, according to the formula, was reached in 1799, but according to direct observation, in 1807 and again in 1814; the latter value, however, would certainly place it too late, the observation referring to noon and to a single day. The observations when plotted appear stunted about the time of turn in the secular motion; omitting the effect of the secondary wave, the primary wave would place the maximum in the year 1812.

† According to Mr. Moureaux's observations (Mémoires divers; observations magnétiques faites à l'observatoire du Parc Saint-Maur, pendant l'année, 1885) the decrease between 1884.5 and 1885.5 was 6′.3

RESULTS FOR GROUP I.—EASTERN SERIES.

Tabular values of magnetic declinations. Computed magnetic declination at each station for every tenth year of the series, and after 1850 for every fifth year. A plus sign signifies westerly declination, a minus sign easterly declination. The *first* tabular result for any station indicates that the first observation made there falls between that tabular date and the next one following it.

Year (January 1).	1. Saint John's, Newfoundland.*	2. Quebec, Canada.*	3. Charlottetown, Prince Edward Island.	4. Montreal, Canada.	5. Eastport, Me.*	6. Bangor, Me.	7. Halifax, Nova Scotia.*	8. Burlington, Vt.	9. Hanover, N. H.	10. Portland, Me.	11. Rutland, Vt.	12. Portsmouth, N. H.
	°	°	°	°	°	°	°	°	°	°	°	°
1600	----	----	----	----	+19	----	+18					
10					19		17.3					
20					19		16.5					
30	+20				18.5		15.7					
40	+18.5	+17			+18		+14.9					
1650	+17	+17	----	----	+17.5	----	+14.2					
60	16	17			17		13.5					
70	15	17.5			16		12.9					
80	14	17.5			15		12.4					
90	+13	+17.0			+14.5		+12.0					
1700	+13	+16.5	----	----	+13.7	----	+11.8	----	----	+12.1		
10	13	15.5			13.0		11.7			11.4		
20	13.5	14.3			12.3		11.7			10.6		
30	14	13.3			11.9		11.8			9.9		
40	+15	+12.5		+12.0	+11.6		+12.1			+ 9.3		
1750	+16	+12.1	----	+10.7	+11.4	----	+12.5	----	----	+ 8.8	----	----
60	17.5	12.1		9.7	11.4		13.0		+ 7.2	8.41		
70	19	12.2		9.0	11.6		13.7		6.6	8.18		+ 7.9
80	20.5	12.2		8.6	12.0		14.4		6.1	8.12	+ 7.1	7.5
90	+22	+12.2		+ 8.3	+12.6		+15.1	+ 7.4	+ 5.8	+ 8.23	+ 6.6	+ 7.4
1800	+23.5	+12.1	----	+ 8.0	+13.2	+10.9	+15.9	+ 7.3	+ 5.8	+ 8.50	+ 6.3	+ 7.4
10	25	12.1		7.8	14.0	11.4	16.7	7.2	6.0	8.92	6.23	7.7
20	26.5	12.3		7.9	14.8	12.1	17.4	7.49	6.5	9.46	6.46	8.1
30	28.0	12.9	+19.3	8.4	15.6	12.8	18.2	8.14	7.2	10.10	6.93	8.72
40	+29.0	+13.8	+20.7	+ 9.4	+16.4	+13.6	+18.9	+ 8.95	+ 7.9	+10.82	+ 7.61	+ 9.47
1850	+29.9	+14.9	+21.9	+10.7	+17.1	+14.4	+19.4	+ 9.66	+ 8.82	+11.56	+ 8.46	+10.28
55	30.2	15.5	22.4	11.4	17.5	14.8	19.7	9.96	9.31	11.92	8.93	10.70
60	30.5	16.0	22.8	12.0	17.79	15.2	19.9	10.26	9.80	12.29	9.41	11.12
65	30.7	16.5	23.2	12.5	18.08	15.5	20.1	10.60	10.28	12.64	9.91	11.53
70	+30.8	+16.9	+23.4	+13.0	+18.32	+15.9	+20.3	+10.98	+10.76	+12.97	+10.41	+11.94
1875	+30.8	+17.2	+23.6	+13.5	+18.53	+16.19	+20.5	+11.42	+11.24	+13.29	+10.90	+12.32
80	30.8	17.4	23.7	13.8	18.71	16.48	20.6	11.91	11.68	13.58	11.38	12.68
85	30.7	17.5	23.7	14.1	18.84	16.73	20.7	12.41	12.1	13.85	11.84	13.00
90	30.5	17.5	23.7	14.4	18.92	16.95	20.7	12.85	12.5	14.08	12.26	13.3
95	+30.3	+17.5	+23.5	+14.7	+19.0	+17.1	+20.7	+13.2	+12.8	+14.3	+12.6	+13.5
1900	+29.9	+17.5	+23.3	+15.0	+19.0	+17.3	+20.7	+13.5	+13.1	+14.4	+13.0	+13.7

*Results for seventeenth century very doubtful, and at all stations the values for the year 1900 are but rough predictions.

RESULTS OF GROUP I.—EASTERN SERIES—Continued.

Year (January 1).	13. Chesterfield, N.H.	14. Newburyport, Mass.	15. Williamstown, Mass.	16. Albany, N. Y.	17. Salem, Mass.	18. Oxford, N. Y.	19. Cambridge, Mass.	20. Boston, Mass.	21. Provincetown, Cape Cod, Mass.*	22. Providence, R. I.	23. Hartford, Conn.	24. New Haven, Conn.
	°	°	°	°	°	°	°	°	°	°	°	°
1600	----	----	----	----	----	----	----	----	----			
10												
20												
30									+13			
40									+13			
1650	----	----	----	----	----	----	----	----	+12.5			
60									12			
70									11.5			
80									11			
90									+10.5			
1700	----	----	----	----	----	----	+ 9.8	+10.1	+10	----		
10							9.2	9.4	9	+10.4		
20							8.7	8.7	8.5	9.5		
30							8.2	8.1	8	8.8		
40							+ 7.82	+ 7.6	+ 7.4	+ 8.4		
1750	----	+ 8.0	+ 7.5	----	+ 7.8	----	+ 7.46	+ 7.1	+ 7.0	+ 7.8	----	+ 6.8
60		7.5	6.8		7.1		7.17	6.8	6.8	7.0		6.1
70		7.21	6.3		6.6		6.96	6.6	6.6	6.3		5.6
80		7.07	5.9		6.2		6.86	6.5	6.7	6.0	+5.4	5.1
90		+ 7.07	+ 5.7		+ 5.9	+3.01	+ 6.90	+ 6.65	+ 6.9	+ 6.2	+5.2	+ 4.8
1800	----	+ 7.26	+ 5.7	----	+ 6.3	+2.96	+ 7.10	+ 6.90	+ 7.2	+ 6.46	+5.16	+ 4.7
10	+ 6.0	7.60	5.9	+ 5.41	6.6	3.10	7.46	7.29	7.7	6.54	5.24	4.7
20	6.4	8.07	6.3	5.81	7.2	3.40	7.97	7.78	8.2	6.71	5.46	5.0
30	7.0	8.65	6.8	6.35	7.9	3.87	8.60	8.37	8.88	7.29	5.80	5.39
40	+ 7.7	+ 9.31	+ 7.4	+ 7.00	+ 8.7	+4.46	+ 9.29	+ 9.01	+ 9.56	+ 8.24	+6.24	+ 5.95
1850	+ 8.5	+10.02	+ 8.1	+ 7.74	+ 9.64	+5.14	+ 9.99	+ 9.67	+10.25	+ 9.18	+6.77	+ 6.61
55	9.0	10.37	8.5	8.12	10.11	5.51	10.33	10.00	10.59	9.53	7.06	6.97
60	9.4	10.72	8.8	8.49	10.58	5.89	10.63	10.33	10.91	9.78	7.36	7.35
65	9.9	11.06	9.2	8.86	11.04	6.26	10.92	10.64	11.21	10.00	7.68	7.72
70	+10.3	+11.39	+ 9.6	+ 9.23	+11.48	+6.65	+11.17	+10.94	+11.5	+10.21	+7.99	+ 8.10
1875	+10.8	+11.70	+10.0	+ 9.57	+11.90	+7.02	+11.40	+11.22	+11.8	+10.47	+8.30	+ 8.47
80	11.2	11.99	10.3	9.90	12.29	7.38	11.59	11.47	12.0	10.79	8.62	8.84
85	11.6	12.25	10.6	10.19	12.7	7.72	11.74	11.7	12.2	11.17	8.92	9.19
90	12.0	12.48	10.9	10.46	13.0	8.05	11.9	11.9	12.4	11.56	9.2	9.52
95	+12.3	+12.7	+11.2	+10.7	+13.2	+8.35	+12.0	+12.1	+12.5	+11.9	+9.5	+ 9.8
1900	+12.6	+12.8	+11.4	+10.9	+13.5	+8.6	+12.0	+12.2	+12.6	+12.1	+9.8	+10.1

* Results for seventeenth century very doubtful, and at all stations the values for 1900 are but rough predictions.

RESULTS OF GROUP I.—EASTERN SERIES—Continued.

Year (January 1).	25. Nantucket, Mass.	26. Cold Spring Harbor, N. Y.	27. New York City, N. Y.*	28. Bethlehem, Pa.	29. Huntingdon, Pa.	30. New Brunswick, N. J.	31. Jamesburg, N. J.	32. Harrisburg, Pa.	33. Hatboro', Pa.	34. Philadelphia, Pa.	35. Chambersburg, Pa.	36. Baltimore, Md.
	°	°	°	°	°	°	°	°	°	°	°	°
1600	----	----	+8									
10			8.5									
20			9									
30			9.5									
40			+9.6									
1650	----	----	+9.7	----	----	----	----	----	----	----	----	----
60			9.7									
70			9.7									+5.7
80			9.6						+8.3			5.8
90			+9.1						+8.2			+5.7
1700	+ 9.1	----	+8.5	----	----	----	----	----	+7.9	+8.2	----	+5.4
10	8.4		7.8						7.5	7.8		5.0
20	7.8		7.3						7.0	7.4		4.5
30	7.3		6.8						6.4	6.8	+4.45	3.9
40	+ 6.8		+6.3						+5.7	+6.2	+3.83	+3.2
1750	+ 6.4	+5.8	+5.6	+6.1	+3.9	----	----	----	+4.8	+5.3	+3.18	+2.6
60	6.2	5.4	5.0	5.3	3.2		+4.49		3.9	4.4	2.45	2.0
70	6.1	5.0	4.6	4.5	2.5		3.93		3.1	3.6	1.64	1.46
80	6.2	4.77	4.4	3.7	1.8		3.49		2.4	2.8	0.82	1.04
90	+ 6.4	+4.67	+4.4	+3.1	+1.33		+3.21	—0.1	+2.0	+2.3	+0.12	+0.76
1800	+ 6.8	+4.72	+4.3	+2.6	+0.99	+2.54	+3.09	+0.0	+1.8	+2.1	—0.35	+0.64
10	7.2	4.90	4.5	2.3	0.84	2.93	3.15	0.3	2.0	2.16	0.48	0.68
20	7.7	5.21	4.61	2.3	0.88	3.43	3.38	0.8	2.5	2.44	—0.28	0.88
30	8.74	5.63	4.98	2.5	1.11	4.02	3.77	1.4	3.0	2.91	+0.17	1.23
40	+ 8.96	+6.13	+5.61	+2.9	+1.52	+4.66	+4.28	+2.2	+3.7	+3.46	+0.75	+1.70
1850	+ 9.57	+6.69	+6.31	+3.46	+2.07	+5.32	+4.91	+2.94	+4.35	+4.07	+1.38	+2.27
55	9.87	6.99	6.62	3.81	2.60	5.66	5.25	3.33	4.6	4.39	1.70	2.58
60	10.15	7.28	6.91	4.19	2.74	5.98	5.60	3.71	5.0	4.73	2.02	2.90
65	10.40	7.58	7.16	4.58	3.10	6.29	5.96	4.08	5.3	5.08	2.35	3.23
70	+10.64	+7.87	+7.40	+5.00	+3.48	+6.59	+6.32	+4.43	+5.7	+5.44	+2.70	+3.55
1875	+10.86	+8.15	+7.64	+5.42	+3.85	+6.87	+6.67	+4.75	+6.2	+5.81	+3.06	+3.87
80	11.04	8.41	7.90	5.85	4.23	7.12	+7.01	5.05	6.7	6.20	3.44	4.17
85	11.19	8.66	8.18	6.26	4.60	7.35	7.35	5.30	7.1	6.59	3.84	4.47
90	11.31	8.89	8.49	6.66	4.95	7.55	7.65	5.52	7.6	6.97	4.25	4.74
95	+11.40	+9.1	+8.8	+7.03	+5.3	7.72	+7.94	+5.7	+7.9	+7.4	+4.65	+5.00
1900	+11.5	+9.3	+9.1	+7.4	+5.6	+7.9	+8.2	+5.8	+8.0	+7.7	+5.0	+5.2

* Results for the seventeenth century very doubtful, and at all stations the values for 1900 are but rough predictions.

RESULTS OF GROUP I.—EASTERN SERIES—Continued.

Year (January 1).	37. Washington, D.C.	38. Cape Henlopen, Del.	39. Williamsburg, Va.	40. Cape Henry, Va.	41. New Berne, N. C.	42. Milledgeville, Ga.	43. Charleston, S. C.	44. Savannah, Ga.	45. Paris, France.	46. St. George's Town, Bermuda Islands.	47. Rio de Janeiro, Brazil.
	°	°	°	°	°	°	°	°	°	°	°
1540	-----	-----	-----	-----	-----	-----	-----	-----	— 6.5		
1550	-----	-----	-----	-----	-----	-----	-----	-----	— 7.4		
60									8.8		
70									10.0		
80									10.6		
90									—10.4		
1600	-----	-----	-----	-----	-----	-----	-----	-----	— 9.3		
10									7.7		
20									6.1		
30									4.6		
40									— 3.3		
1650	-----	-----	-----	-----	-----	-----	-----	-----	— 2.3		
60									— 1.1		
70									+ 0.4		
80									2.5		
90			+4.7						+ 4.9		
1700	-----	+6.4	+4.6	+4.6	-----	-----	+0.0	-----	+ 7.6		
10		5.8	4.4	4.3			—0.5		10.3		
20		5.2	4.0	3.9			1.2		12.6		
30		4.4	3.5	3.4			1.8		14.3		
40		+3.7	+2.9	+2.9			—2.5		+15.7		
1750	+2.1	+2.9	+2.3	+2.3	—0.1	-----	—3.1	-----	+16.8	----	----
60	1.5	2.3	1.65	1.8	0.7		3.7		18.1		—7.63
70	1.0	1.7	1.05	1.2	1.2		4.1		19.6		7.35
80	0.6	1.2	0.52	0.8	1.6		4.4		21.2		6.89
90	+0.3	+0.9	+0.10	+0.45	—1.8		—4.55		+22.3		—6.25
1800	+0.2	+0.8	—0.17	+0.24	—1.9	—5.0	—4.55	-----	+22.6	----	—5.44
10	0.2	0.9	0.28	0.17	1.9	5.3	4.37	—4.7	22.3		4.49
20	0.4	1.1	—0.22	0.25	1.6	5.6	4.05	4.7	21.9		3.43
30	0.75	1.5	+0.01	0.47	1.25	5.6	3.59	4.5	21.8	+6.9	2.22
40	+1.08	+2.00	+0.38	+0.82	—0.75	—5.55	—3.03	—4.2	+21.8	+6.86	—0.94
1850	+1.84	+2.64	+0.88	+1.27	—0.17	—5.33	—2.39	—3.78	+20.9	+6.95	+0.40
55	2.23	2.99	1.16	1.53	+0.14	5.17	2.06	3.54	20.1	7.02	1.08
60	2.50	3.36	1.47	1.80	0.46	4.98	1.73	3.27	19.1	7.15	1.77
65	2.68	3.73	1.78	2.08	0.79	4.76	1.39	2.98	18.2	7.30	2.46
70	+2.92	+4.11	+2.10	+2.37	+1.11	—4.51	—1.07	—2.68	+17.5	+7.46	+3.15
1875	+3.30	+4.49	+2.43	+2.66	+1.42	—4.24	—0.75	—2.37	+17.0	+7.66	+3.84
80	3.75	4.86	2.75	2.94	1.72	3.96	0.45	2.06	16.6	7.89	4.51
85	4.12	5.2	3.06	3.22	2.01	3.66	—0.17	1.76	16.1	8.14	5.18
90	4.33	5.6	3.3	3.5	2.27	3.36	+0.09	1.45	15.1	8.4	5.83
95	+4.4	+5.9	+3.6	+3.7	+2.5	—3.05	+0.3	—1.2	+13.8	+8.7	+6.5
1900	+4.6	+6.2	+3.9	+3.9	+2.7	—2.7	+0.5	—0.9	-----	-----	-----

All values for 1900 are but rough predictions.

GROUP II.—*Series of Magnetic Stations mainly in the central part of the United States between the Appalachian and Rocky Mountain ranges.*

The stations of this central series are distributed over the region south of the Hudson Bay and over the area between the eastern and western mountain ranges inclosing the drainage of the Gulf of Mexico; added to it are two stations in the West Indies and one in Central America.

Observations were collected and discussed for secular change of declination at the following places; the stations are arranged in the order of decreasing latitude:

1. York Factory, Hudson Bay, Brit. Poss.
2. Fort Albany, Brit. N. A.
-- Michipicoten, Ontario, Canada.
3. Duluth, Minn., and Superior City, Wis.
4. Sault de Ste. Marie, Mich.
5. Pierrepont Manor, N. Y.
6. Toronto, Canada.
7. Grand Haven, Mich.
-- Madison, Wis.
8. Milwaukee, Wis.
9. Buffalo, N. Y.
10. Detriot, Mich.
11. Ypsilanti, Mich.
12. Erie, Pa.
13. Chicago, Ill.
14. Michigan City, Ind.
15. Cleveland, Ohio.
16. Omaha, Nebr.
17. Beaver, Pa.
18. Pittsburgh, Pa.
19. Denver, Colo.
20. Marietta, Ohio.
21. Athens, Ohio.
22. Cincinnati, Ohio.
23. Saint Louis, Mo.
24. Nashville, Tenn.
25. Florence Ala.
-- Natchez, Miss.
26. Mobile, Ala.
-- Pensacola, Fla.*
27. New Orleans, La.
28. San Antonio, Tex.
29. Key West, Fla.
30. Havana, Cuba.
31. Kingston, Port Royal, Jamaica.
32. Barbados, Caribbee Islands.
33. Panama, New Granada.

The first column of the record for any station contains the running number of the observed values made use of in the discussion, the second the date of the observation, the third the observed value, and the fourth the name of the observer, the geographical position of the station, the reference to publication, and other pertinent remarks. Unless otherwise stated, unit weight ($w=1$) is given in the computation to each observation.

1.—YORK FACTORY, HUDSON BAY.

$\phi=56° 59'.9$ $\lambda=92° 26'$ W. of Gr.

		° ′	
1	1725--	19 W.	Capt. Middleton; Hansteen's Magnetismus der Erde, 1819. [$w=\frac{1}{4}$—SCH.]
2	1787--	5 W.	Hansteen's isogonic chart; reference as above.
3	1819, September.	6 00.3 E.	Sir John Franklin, in $\phi=57° 00'$, 92° 26′ W. Gen. Sir Edw. Sabine, Proc. Roy. Soc., 1858, and Conts. to Terr. Mag. No. xiii, Phil. Trans. Roy. Soc., 1872.
4	1843, July 24, 26.	9 00.6	Capt. Lefroy, R. E.; Sir J. H. Lefroy's Magnetic Survey of Canada, etc., London, 1883.
5	1857, August.	7 37	Capt. Blakiston, R. E.; reference as before.
	1878--	5 30	Alfred R. C. Selwyn, director Geological Survey of Canada; Report of 1878-'79, appendix vii, Montreal, 1880, at N. E. side of fort; this locality appeared to be subject to local attraction. [Value not used.—SCH.]
6	1879--	7 00	Observer and reference as before; at the S. W. side of fort.
7	1884, September 12, 13.	6 39.8 E.	Otto J. Klotz, D. T. S. Communicated by the Hon. E. Deville, Dept. of the Int., Ottawa. At Capt. Lefroy's station, in $\phi=56° 59'.9$, $\lambda=92° 26'$ W. See also letter of O. J. Klotz to this office, dated March 19, 1885.

* This station inserted while the paper was going through the press.

GROUP II.—*Collection of Magnetic Declinations, Central Series*—Continued.

2.—FORT ALBANY, BRIT. NORTH AMERICA.

$\phi=52^\circ 22'$ $\lambda=82^\circ 38'$ W. of Gr.

		° ′	
1	1668..	19 15 W.	C. Hansteen in his Magnetismus der Erde, Christiania, 1819; in $\phi=52^\circ 22'$, $\lambda=82\frac{1}{2}^\circ$. "The declination has increased between 1668 and 1730, and decreased from 1730 to the present." [This remark appears to be borne out by the results found at York Factory.—SCH.]
2	1730, August 22.	23 00	Captain Middleton. Reference as above. In $\phi=52^\circ 22'$, $\lambda=82^\circ 38'$.
3	1774, September 14.	17 00	Hutchins. Reference and position as above.
4*	1840–45.	7½	Genl. Sir Edw. Sabine's isogonic map in Phil. Trans. Roy. Soc., 1872.
5*	1880..	11 W.	English Admiralty chart of curves of equal magnetic variation.
	1880..	10 W.	Deutsche Seewarte, lines of equal magnetic variation. [Mean, 10½° W. Used with $w=2$—SCH.]

* The values are temporarily introduced in the absence of direct observations.

MICHIPICOTEN, ONTARIO, CANADA.

$\phi=47^\circ 56'.0$ $\lambda=84^\circ 50'.6$ W. of Gr.

(Garden, Hudson Bay Company's ground.)

		° ′	
1	1824..	4 33 E.	Capt. Bayfield, R. N., Sir Edw. Sabine, in Phil. Trans. Roy. Soc., 1872, Cont'n xiii. Fort Michipicoten is placed in $\phi=47^\circ 56'$, $\lambda=85^\circ 05'$ W.
2	1844, October 30.	0 20.3 E.	Lieut. J. H. Lefroy, R. E.; Gen. Sir J. H. Lefroy's Diary of Magnetic Survey of Canada, etc., London, 1883, p. 167; in $\phi=47^\circ 56'.0$, $\lambda=84^\circ 54'$ W. [In foot-note, p. 72, it is pointed out that the value heretofore given (3° 49′ E.) was erroneous.—SCH.]
3	1880, July 21, September 9.	1 20.5 W.	Lieut. S. W. Very, U. S. N., Actg. Asst. Coast and Geodetic Survey. Position as in heading. Coast and Geodetic Survey Report for 1881, App. 9. [Results at this station insufficient for discussion; the corrected value for 1844 appears less probable than the old value.—SCH.]

3.—DULUTH, MINN., AND SUPERIOR CITY, WIS.

$\phi=46^\circ 45'.5$, $\lambda=92^\circ 04'.5$ W. of Gr. $\phi=46^\circ 39'.9$, $\lambda=92^\circ 04'.2$ W. of Gr.

		° ′	
	1824.5.	12 30 E.	Capt. Bayfield, at river St. Louis, near Fond du Lac, in $\phi=46^\circ 43'$, $\lambda=92^\circ 10'$ W. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., 1872, Cont'n xiii. [To reduce to Duluth subtract 10′; not used.—SCH.]
1	1859, July.	9 25.2	Lieut. W. P. Smith, U. S. Survey of N. and N. W. Lakes; Capt. G. G. Meade, Detroit, 1859. At Minnesota Point, in $\phi=46^\circ 46'$, $\lambda=92^\circ 14'$ W.
2	1861..	10 12	U. S. Survey of N. and N. W. Lakes.
3	1870, September 20.	10 30	Gen. C. B. Comstock, U. S. Lake Survey; at Superior City, in $\phi=46^\circ 43'$, $\lambda=92^\circ 04'$ W. Gen. Comstock's letter of May 7, 1875.
4	1871, June 20, 27.	10 40	Gen. C. B. Comstock; reference as before. In $\phi=46^\circ 45'.4$, $\lambda=92^\circ 04'.5$ W. At North Base, Minnesota Point.
	1873, August 13, 15.	11 51.8	Capt. A. N. Lee, U. S. E.; at Duluth; Report of Chief of Engineers, 1874, App. C C, and letter of Gen. Comstock as above. In $\phi=46^\circ 45'.5$, $\lambda=92^\circ 04'.5$ W. [Not used.—SCH.]
5	1880, August 21, 23.	9 45.4 E.	J. B. Baylor, U. S. Coast and Geodetic Survey; at Superior City, in $\phi=46^\circ 40'$, $\lambda=92^\circ 04'$ W. Coast and Geodetic Survey Report for 1881, App. 9. [To this value double weight is given.—SCH.]

GROUP II.—*Collection of Magnetic Declinations, Central Series.*—Continued.

4.—SAULT DE STE. MARIE, MICH.

$\phi=46° 29'.9$ $\lambda=84° 20'.1$ W. of Gr.

(Garden of Fort Brady.)

		° ′	
1	1790..	0 E.	Alex. Mackenzie; Voyages through the continent of America, London, 1801. Falls of Ste. Marie, in $\phi=46° 31'$, $\lambda=84° 00'$ W.
	1819, May 2.	2 32.8	Sir John Franklin; Sir J. H. Lefroy's Magnetic Survey of Canada, etc., London, 1883. [Not used.—SCH.]
2	1843..	1 08	Lieut. J. H. Lefroy; Sir Edw. Sabine, in Phil. Trans. Roy. Soc., Cont'n xiii, 1872.
3	1844, November 4.	1 01.1	Lieut. J. H. Lefroy; Sir J. H. Lefroy's Magnetic Survey of Canada, etc., London, 1883. In Phil. Trans. Roy. Soc., 1872, position in $\phi=46° 31'$, $\lambda=84° 32'$ W.
4	1845..	0 46	Observer, position, and reference as before.
5	1846, November.	0 40	Lieut. G. C. Westcott, U. S. A. Information from Mr. J. B. Baylor.
6	1856, September 29.	0 32.1 E.	Karl Friesach; Kais. Acad. der Wiss., vol. 29, Vienna, 1858; position assigned $\phi=46° 30'$, $\lambda=84° 34'$ W.
7	1873, July 22, 23.	0 04.9 W.	Capt. A. N. Lee, U. S. E.; Survey of the N. and N. W. Lakes, Gen. C. B. Comstock in charge. MS. of 1873, also Report of Chief of Engineers, U. S. A., 1874, App. C C. In $\phi=46° 30'$, $\lambda=84° 20'.0$ W.
8	1879, November 12.	1 01.0	City Surveyor at Fort Brady. Information from Mr. J. B. Baylor.
9	1880, July 11, 13, 14, 17, 19.	0 53.7	Lieut. S. W. Very, U. S. N.; Actg. Asst. Coast and Geodetic Survey. In vegetable garden of Fort Brady; in $\phi=46° 29'.9$, $\lambda=84° 20'.1$ W. Coast and Geodetic Survey Report for 1881, App. 9.
	1880, August 6, 7.	1 04.5 W.	J. B. Baylor, U. S. Coast and Geodetic Survey. In military post garden, about 30 meters N. W. of Lieut. Very's position of 1880. Reference as above. [Mean, 0° 59′.1 W.—SCH.]

5.—PIERREPONT MANOR, JEFFERSON COUNTY, N. Y.

$\phi=43° 44'.5$ $\lambda=76° 03'.0$ W. of Gr.*

		° ′	
1	1823, September 18.	2 16.1 W.	W. C. Pierrepont. Letter of Verplanck Colvin of May 5, 1871; also, report of the Adirondack State land survey, 1886, Verplanck Colvin superintendent, Albany, 1886. [Compared with an observation at Lowville in 1821, viz, 4° 30′ W., the Pierrepont Manor value appears too small. A table of values in the Adirondack Survey Reports for 1884 and 1886, giving observed and interpolated declinations between 1797 and 1874, is very defective.† The weight ⅓ is assigned to the 1823 observation.—SCH.]
2	1847, September 18.	4 23	Letter of V. Colvin of May 5, 1871, and his reports of Adirondack Surveys of 1884, 1886.
3	1856, November 25.	5 10.0	
4	1860, July 15, 16.	5 36	
5	1863, July 10.	5 44 W.	

* The geographical position here given depends on that of Mannsville as determined by the U. S. Lake Survey.

† The table gives zero declination for October 1, 1797. This mistake originally arose, I suppose, by confusing the annual change, which was then about zero, with the declination itself. Mr. Colvin himself points out elsewhere in his report of 1886 that the declination was *not zero* in the Adirondack region about that time, but reprints the table uncorrected.

GROUP II.—*Collection of Magnetic Declinations, Central Series*—Continued.

PIERREPONT MANOR, JEFFERSON COUNTY, N. Y.—Continued.

		° ′	
6	1864, April 12.	5 50 W.	Letter of V. Colvin of May 5, 1871, and his reports of Adirondack Surveys of 1884, 1866
7	1865, {May, June} 4.	6 00	
8	1866, September 11.	6 15	
9	1867, July 27.	6 10	
10	1868, May 12.	6 10	
11	1869, May 11.	6 18	
12	1870, May 27, September 21.	6 03.5	
13	1874.	6 44	
	1874, October 20.	6 11.9 W.	Dr. T. C. Hilgard, Observer to U. S. Coast Survey. Station half a mile S. W. of village, stone in pasture on Pierrepont's meridian line. [Weighted value, 6° 33′ W. adopted.—SCH.]

6.—TORONTO, ONTARIO, CANADA.

$\phi=43° 39'.4$ $\lambda=79° 23'.5$ W. of Gr.

(The Magnetic Observatory.*)

		° ′	
1	1840, January.	1 27 W.	Capt. C. J. B. Riddell, R. A. Phil. Trans. Roy. Soc., 1849.
2	1841.5	1 14.3	Vol. i, Toronto Mag'l and Met'l Observations, p. xi. Mean annual declinations. In the abstract of results, published in 1875, 1° 19′.1 W. is given for 1842.5
3	1842.5	1 18.9	
4	1845.5	1 29.1	Vol. ii, Toronto Mag'l and Met'l Observations, pp. iii–v. Mean annual declinations.
5	1846.5	1 30.8	
6	1847.5	1 33.2	
7	1848.5	1 35.4	
8	1849.5	1 36.9	
9	1850.5	1 38.6	
10	1851.5	1 40.9	
11	1853, July and August.	1 46.1	These values are corrected for annual and secular variations.
12	1854, February, March, April, and June.	1 48.0	
13	1855, August to December, both inclusive.	1 52.3	
14	1856.5	1 56.3	Mean annual declinations.
15	1857.5	2 00.5	
16	1858.5	2 04.5	
17	1859.5†	2 07.4	
18	1860.5	2 10.6 W.	

* For values in the above table prior to 1869, see also results published by G. T. Kingston, M. A., director of the Magnetic Observatory, Toronto, in the Canadian Journal, especially two communications, "Monthly absolute values of the magnetic elements at Toronto, from 1856 to 1864, inclusive," and "Monthly absolute values of the magnetic elements at Toronto, from 1865 to 1868, inclusive, with the annual means from 1841 to 1868." Director Kingston placed the observatory in $\phi=43° 39'.4$, $\lambda=79° 23'.3$ W.

† June 25–30, 1859, Lieut. W. P. Smith observed the declination 2° 11′.6 W. Capt. G. G. Meade, U. S. Survey of the N. N. and W. Lakes, Detroit, 1859. [Not used.—SCH.]

GROUP II.—*Collection of Magnetic Declinations, Central Series*—Continued.

TORONTO, ONTARIO, CANADA—Continued.

		° ′	
19	1861.5	2 14.3 W.	Mean annual declinations.
20	1862.5	2 15.7	
21	1863.5	2 19.1	
22	1864.5	2 21.9	
23	1865.5	2 24.8	
24	1866.5	2 27.6	
25	1867.5	2 29.8	
26	1868.5	2 33.2	
27	1869.5	2 37.1	Abstracts and Results of magnetical and meteorological observations at the Magnetic Observatory, Toronto, Canada, from 1841 to 1871, inclusive. Toronto, 1875. Mean annual declinations.
28	1870.5	2 41.9	
29	1871.5	2 47.9	
30	1872.5	2 53.0	Mean annual declinations communicated Feb. 28, 1881, by Mr. Chas. Carpmael, director of the Toronto Magnetic Observatory and Supt. of the Meteorological Service, Toronto, Ontario. [In a recent communication to the Supt. of the Naut. Alm. he gives the longitude 79° 23′ 39″—SCH.]
31	1873.5	2 58.3	
32	1874.5	3 04.1	
33	1875.5	3 11.7	
34	1876.5	3 18.5	
35	1877.5	3 24.9	
36	1878.5	3 31.4	
37	1879.5	3 37.3	
38	1880, October 18.	3 41.1	Communicated by Mr. C. Carpmael, director of the observatory, Jan. 14, 1881.
39	1884. August.	3 57.2 W.	Communicated by Mr. Otto J. Klotz. Proceedings of the Association of Dominion Land Surveyors, Ottawa, 1885.

7.—GRAND HAVEN, MICH.

$\phi=43° 05'.2$ $\lambda=86° 12'.6$ W. of Gr.

		°	
1	1825..	$3\frac{3}{4}$ to 6° E.	L. Lyon; at Grand River in $\phi=42° 55'$, $\lambda=86° 10'$ W. Prof. E. Loomis, Sill. Jour., vol. xxxix, 1840.
		° ′	
2	1837..	4 30	Geological Report; reference as above. In $\phi=42° 55'$, $\lambda=86° 10'$ W. [$w=2$—SCH.] } Weighted mean, 5°.08 E.
		6 15	Geological Report; reference as above. In $\phi=43° 19'$, $\lambda=85° 59'$ W. [$w=1$—SCH.]
3	1859, August 18.	4 24.2	Lieut. W. P. Smith, U. S. Survey of N. and N. W. Lakes; report by Capt. G. G. Meade, Detroit, 1859. In $\phi=43° 05'.2$, $\lambda=86° 12'.6$ W.
4	1865..	4 15	U. S. Survey of N. and N. W. Lakes. MS. by Col. Reynolds, Dec., 1865. In $\phi=43° 04'$, $\lambda=86° 13'$ W.
	1865, September.	4 20	J. de la Camp; Prof. Papers, U. S. Eng's No. 24, Washington, 1882. In $\phi=43° 05'$, $\lambda=86° 12'$. [Mean, 4° 17′.5 for 1865.6—SCH.]
5	1871, July 31.	3 33	L. Foote; Prof. Papers, U. S. Eng's No. 24, Washington, 1882. In $\phi=43° 04'$, $\lambda=86° 14'$.
6	1873, August 28, 29.	3 28.2	Capt. A. N. Lee, U. S. Survey of N. and N. W. Lakes; MS. of 1873. See also Report of Chief of Engineers for 1874.
7	1880, July 20, 21.	2 25.7 E.	J. B. Baylor, U. S. Coast and Geodetic Survey. In grounds of the county court-house, $\phi=43° 04'.7$, $\lambda=86° 12'.6$ W. Coast and Geodetic Survey Report for 1881, App. 9.

Group II.—*Collection of Magnetic Declinations, Central Series*—Continued.

MADISON, WIS.

$\phi=43° 04'.6$ $\lambda=89° 24'.2$ W. of Gr.

(University of Wisconsin.)

		° ′		
1	1839, November 2.	7 30 E.	Dr. J. Locke; in survey of "Mineral Lands," Exec. Doc., 1839-40, vol. vi, 1839. In $\phi=43° 03'$, $\lambda=89° 11'$ W.	
2	1841, September.	7 30	Dr. Locke and Prof. Loomis; southeast of the State-house (or Capitol), in $\phi=43° 04'.5$, $\lambda=89° 23'.0$ W. Phil. Trans. Roy. Soc., 1872. [The long. given, 89° 06′, is much in error.—Sch.]	
	1876, October 10, 11, 12, 13, 14.	6 59.7	F. E. Hilgard, observer for U. S. Coast Survey; Coast and Geod'c Survey Rep. for 1881, App. 9. [Not used.—Sch.]	Station near and south of University central building, in $\phi=43° 04'.5$, $\lambda=89° 24'.2$ W. [This place was found affected by the erection of a water tank and of vertical pipes, hence a new station was established in 1878 on the University farm,* about 1 st. mile west.—Sch.]
	1877, August 30, September 21.	6 44.9	A. Braid, U. S. Coast Survey. Reference as above. [Not used.—Sch.]	
3	1878, August 29, 30.	6 34.0	Dr. Gustavus Hinrichs; in connection with magnetic survey of Iowa. MS. communication.	
	1878, September 8, 9, 10, 11, 12, 13.	6 31.8	W. Suess, observer for U. S. Coast Survey; Coast and Geodetic Survey Report for 1881, App. 9.	
	1878, November 22, 23, 25.	6 22.9	J. B. Baylor, U. S. Coast and Geod'c Survey. Reference as before. [Corrected for local attraction; weight assigned, ½.—Sch.].	
4	1879, September 22 to October 11.	6 26.8	David Mason, observer for Coast and Geod'c Survey. Station on University Hill, south of building,	
5	1880, September 15 to 22.	6 20.9 E.	Observer, position, and reference as above.	

* The observations on the University farm, in $\phi=43° 04'.5$, $\lambda=89° 25'.2$ W., gave the following results (see Coast and Geod'c Survey Report for 1881, App 9):

	° ′			° ′
1878, November 13, 14, 15.	6 31.7 E.	J. B. Baylor, observer	[Combining the two stations, the following mean values were adopted:	For 1878.8, 6 31.3 E.
1879, October 6, 7, 8, 9.	6 30.9	Dav. Mason, observer		1879.7, 6 28.8
1880, September 23 to 28.	6 22.9	Dav. Mason, observer		1880.7, 6 21.9
1881, December 16, 17, 18, 19.	6 21.0	W. Suess, observer		1881.9, 6 19.8 E. —Sch.]
1888, August 31.	5 53.2 E.	J. B. Baylor, asst. C. & Geod. Survey; MS. in archives.		

[From the values collected at this station nothing further can be deduced than the average annual change, which was +3′.8 between 1878 and 1888—Sch.]

8.—MILWAUKEE, WIS.

$\phi=43° 02'.5$ $\lambda=87° 54'.2$ W. of Gr.

		° ′	
1	1859, August 20	6 20.1 E.	Lieut. W. P. Smith, U. S. Survey of N. and N. W. Lakes; communicated by Capt. G. G. Meade, Detroit, 1859. In $\phi=43° 02'.8$, $\lambda=87° 55'.1$ W.
2	1871, May.	6 43	Major D. C. Houston, U. S. E.; Prof. Papers U. S. Engineers No. 24. Washington, 1882; in $\phi=43° 02'$, $\lambda=87° 54'$.
3	1873, August 22.	6 22.4	Capt. A. N. Lee, U. S. E.; survey of N. and N. W. Lakes, Gen'l C. B. Comstock in charge. MS. received in 1873. Position as above.
4	1882, September.	4 55	Major D. C. Houston, U. S. E.; on breakwater, in $\phi=43° 03'$, $\lambda=87° 55'$. Letter of W. Powrie, surveyor, Sept. 21, 1884.
5	1888, August 25, 27.	4 22.3 E.	J. B. Baylor, asst. C. and Geod. Survey. West of North Point Light-House; in $\phi=43° 04'.0$, $\lambda=87° 52'.6$ MS. in archives.

GROUP II.—*Collection of Magnetic Declinations, Central Series*—Continued.

9.—BUFFALO, N. Y.

$\phi = 42° 52'.8$ $\lambda = 78° 53'.5$ W. of Gr.

(Light-house in the harbor.)

		° ′ W.	
	1789, June 29.	4 06	Seven miles south of Buffalo (creek) in $\phi=42° 45'$, $\lambda=78° 53'$. MS. of a surveyor discovered at the State library, Albany. Information by F. M. Thorn, March 30, 1890. [Not used.—SCH.]
1	1797	0 00	Amry Atwater, surveyor; east end of Lake Erie. MS. collection by Charles Whittlesey; communicated to the Coast Survey March 26, 1860.
2	1798	0 30	Buffalo reservation, lake shore. August Porter, in twenty-second report of Regents of University, New York, Albany, 1869.
3	1837	1 25	R. W. Haskins, in $\phi=42° 53'$, $\lambda=78° 55'$ W. Prof. E. Loomis's collection, Sill. Jour., vol. xxxiv, 1838.
4	1839	1 15	At Fort Erie, $\phi=42° 52'$, $\lambda=78° 59'$ W. U. S. Lake Survey chart.
5	1845	1 25	Capt. J. H. Lefroy; Gen. Sir Edw. Sabine's Contribution xiii, in Phil. Trans. Roy. Soc., 1872.
6	1859, June.	2 56.5	Lieut. W. P. Smith; U. S. Lake Survey, in $\phi=42° 53'$, $\lambda=78° 53'$ W., near south pier. Report of the U. S. Lake Survey, by Capt. G. G. Meade, Detroit, 1859, App. B.
7	1872, June 14.	3 52.4	Capt. A. N. Lee, U. S. Lake Survey, in $\phi=42° 53'$, $\lambda=78° 54'$ W. Report of Chief of Engineers for 1873, magnetic results, 1870–73, pp. 1195–1197.
8	1873, June 4 and 5.	3 58.3	Observer, position, and reference as before.
9	1885, September 17, 18, 19.	5 04.3 W.	J. B. Baylor, subasst. U. S. Coast and Geodetic Survey. At Fort Porter, $\phi=42° 55'$, $\lambda=78° 54'$ W. MS. in Coast and Geodetic Survey archives.

10.—DETROIT, MICH.

$\phi = 42° 20'.0$ $\lambda = 83° 03'.0$ W. of Gr.

		° ′	
1	1810	2 48 E.	J. Mansfield. Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838. Position assigned, $\phi=42° 30'$, $\lambda=82° 58'$ W.
2	1822	3 13	L. Lyons; Prof. E. Loomis's collection in Sill. Jour., vol. xxxix, 1840. Position assigned, $\phi=42° 24'$, $\lambda=82° 58'$ W.
3	1828	2 50	L. Lyons
4	1835	2 10	Geological Report
5	1840	2 00	Geological Report
	1840	1 56	Prof. E. Loomis; Gen. Sir Edw. Sabine, Phil. Trans. Roy. Soc., 1872, Contribution No. xiii.
6	1859, April.	0 42	U. S. Lake Survey. MS. communicated by Col. W. F. Raynolds, U. S. E. Position assigned, $\phi=42° 20'$, $\lambda=83° 03'$ W.
7	1865	0 40	
8	1872, May 8–29.	0 25.2	Capt. A. N. Lee, U. S. A., observer; U. S. Lake Survey, Gen. C. B. Comstock, Superintendent. Report of the Chief of Engineers for 1873, pp. 1195–1197. Position assigned, $\phi=42° 20'.0$, $\lambda=83° 02'.5$ W.
9	1873, May 5–17.	0 17.3	
10	1876, June 3, 6.	0 04.7 E.	Lieut. T. N. Bailey, observer; U. S. Lake Survey; Report of Chief of Engineers for 1877, vol. 2. Position assigned, $\phi=42° 20'$, $\lambda=83° 03'.1$ W.
11	1885, September 2, 3, 4.	0 31.0 W.	J. B. Baylor, subasst. U. S. Coast and Geodetic Survey. MS. in C. and G. S. archives. Rear of Harper Hospital. In $\phi=42° 21'.0$, $\lambda=83° 03'.1$ W.

Group II.—*Collection of Magnetic Declinations, Central Series*—Continued.

11.—YPSILANTI, MICH.*

$\phi=42° 14'$ $\lambda=83° 38'$ W. of Gr.

		° ′		
1	1815..	4 00	E.	Government land surveyors.
2	1825..	3 16		W. Brookfield.
3	1832..	2 40		O. Risdon (?).
4	1838..	2 25		O. Risdon (?).
5	1851..	1 12		C. S. Woodward. 6-inch *transit* needle.
6	1855, January 10.	1 00		C. S. Woodward. Solar compass.
7	1859, February 26.	0 45		C. S. Woodward. 6-inch transit needle.
8	1860, June 11.	0 38		C. S. Woodward. 6-inch transit needle.
9	1863..	0 25	E.	C. S. Woodward. 6-inch transit needle.
10	1875, December 4.	0 30	W.	C. S. Woodward. 5-inch English theodolite.
11	1878..	0 45		C. S. Woodward. 5-inch English theodolite.
12	1881, March 11.	1 00		C. S. Woodward. 5-inch English theodolite.
13	1885, August 18.	1 13		C. S. Woodward. 5-inch English theodolite.
14	1887, April 25.	1 25		C. S. Woodward. 5-inch English theodolite.
15	1888, August 23, 1 p. m.	{ 1 30 1 40	W.	} C. S. Woodward. 5 and 6 inch surveyor's transit. [Value reduced to mean of day +1°.50—Sch.]

* This valuable series of observed declinations was communicated by C. S. Woodward, surveyor; see letter to Superintendent of Sept. 10, 1888.

12.—ERIE, PA.

$\phi=42° 07'.8$ $\lambda=80° 05'.4$ W. of Gr.

(Court-house.)

		° ′		
1	1786, October.	0 32	W.	New York and Pennsylvania boundary line; monument on French Creek, in $\phi=42° 00'$, $\lambda=79° 58'$ W., about 10 miles S. S. E. of Erie. Geological Survey of New York. See also map in the State Dept. of New York on which the observed variations are "protracted by Abm. Hardenberg, one of the Commissioners for the State of New York, Oct. 29, 1787."
2	1793..	0 42.2	E.	Annual report of the Secretary for Internal Affairs, State of Pa., 1885; Harrisburg, 1886.
3	1795..	0 43	E.	Andrew Ellicott; stone monument corner Parade and Front streets, in $\phi=42° 08'.2$, $\lambda=80° 05'.2$ W. American Almanac of 1861, p. 54, Boston, 1861.
4	1841, August 9.	0 30	W.	Dr. A. D. Bache, magnetic survey of Penn'a; Coast and Geodetic Survey Report for 1862, p. 213.
5	1855..	1 33		Annual Report of the Secretary for Internal Affairs, State of Pennsylvania, for 1877; Harrisburg, 1878.
6	1859, April.	1 34		Samuel Low; at meridian line established by him in cemetery. Mean of 9 years of observation, 1855 to 1863, inclusive. From Annual Report of Secretary for Internal Affairs, Commonwealth of Pennsylvania, Harrisburg, 1876, p. 20 A. In $\phi=42° 09'$, $\lambda=80° 05'$ W.
	1859, June.	1 44.4	W.	Lieut. W. P. Smith, U. S. survey of N. and N. W. Lakes; Capt. G. G. Meade in charge. At Presque Isle Harbor, in $\phi=42° 09'.8$, $\lambda=80° 05'.3$ W. [Mean of two values, +1° 39'.2]

Group II.—*Collection of Magnetic Declinations, Central Series*—Continued.

ERIE, PA.—Continued.

		° ′	
7	1862, August 6, 7.	1 33 W.	C. A. Schott, assistant Coast Survey. Same place as in Dr. Bache's survey, near Mr. Reed's house, 7th street, in $\phi=42°\ 07'.5$, $\lambda=80°\ 05'.3$ W. Coast Survey Report for 1862, p. 212.
	1862..	1 30	Samuel Low, observer. Annual Report of Secretary for Internal Affairs of Pa., 1885; Harrisburg, 1886.
8	1867, April.	2 13	Samuel Wilson; at meridian line in cemetery. Mean of 7 years of observation, 1864 to 1870, inclusive. Annual Rep. of Sec'y for Int. Aff. of Pa., 1876.
9	1873, June 12, 13.	2 00.7	Capt. A. N. Lee, U. S. Lake Survey. Report of Chief of Engineers for 1873, pp. 1195–1197; magnetic results 1870 to 1873. In $\phi=42°\ 08'.2$, $\lambda=80°\ 05'.3$ W.
	1873, October.	2 36	Samuel Wilson; at meridian line in cemetery. Mean of 6 years of observation, 1871 to 1876, inclusive. Annual Rep. of the Sec'y for Int. Aff. of Pa., 1876. [Mean, $+2°\ 18'.3$.]
10	1875, October 9.	2 10	A. C. Lamson, in $\phi=42°\ 08'$, $\lambda=80°\ 07'$. Prof. Papers, U. S. Eng's, No. 24, Washington, 1882.
11	1876..	2 50	Annual Report of the Sec'y for Internal Affairs of Pa., 1876.
12	1877, November.	3 00	Annual Report of the Sec'y for Int. Aff. of Pa., 1877; Harrisburg, 1878.
13	1883, November 9.	3 20	Platt, observer; Annual Rep. of the Sec'y for Internal Affairs of Pa., 1885; Harrisburg, 1886.
14	1885, September 11, 12, 14.	3 08.2 W.	J. B. Baylor, subasst. Coast and Geodetic Survey. Marine Hospital, in $\phi=42°\ 09'$, $\lambda=80°\ 05'$ W. MS. in archives of C. and G. S.

13.—CHICAGO, ILL.

$\phi=41°\ 50'.0$ $\lambda=87°\ 36'.8$ W. of Gr.

(Observatory, Dearborn University.)

		° ′	
1	1823..	6 12 E.	Major Long's expedition; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838. Locality assigned, $\phi=42°\ 00'$, $\lambda=87°\ 40'$ W.
2	1857, July 23.	5 46.1	Lieut. Col. J. D. Graham; Pub. Doc. 35th Congress, 1st Sess., No. 42, 1858. In $\phi=41°\ 54'$, $\lambda=87°\ 38'$ W.
3	1878, September 2.	4 33.1	Dr. T. E. Thorpe; grounds of the Chicago University, position as in heading. Proc. Roy. Soc. No. 200, 1880.
4	1888, August 18, 20.	4 07.4 E.	J. B. Baylor, asst. C. and Geod. Survey; near station of 1878. MS. in archives.

GROUP II.—*Collection of Magnetic Declinations, Central Series*—Continued.

14.—MICHIGAN CITY, IND.

$\phi = 41° 43'.4$ $\lambda = 86° 54'.4$ W. of Gr.

(Light-house.)

		° ′	
1	1830.	5 35 E.	Government land surveyors, communicated by C. S. Woodward; letter of Sept. 10, 1888.
2	1857, May 7 to December 31.	3 43	C. S. Woodward, surveyor.
	1859, August 28.	5 22.6	Lieut. W. P. Smith, U. S. Lake Survey; Capt. G. G. Meade in charge, Detroit, 1859. [Mean value, +4° 32′.8 for epoch 1858.7—SCH.]
3	1871, September 11.	4 02	L. Foote; in $\phi = 41° 44'$, $\lambda = 86° 54'$. Prof. Papers U. S. Engineers No. 24, Washington, 1882.
4	1873, August 25, 26.	3 59.0 E.	Capt. A. N. Lee, U. S. Lake Survey; Gen. C. B. Comstock in charge; MS. of 1873.

15.—CLEVELAND, OHIO.

$\phi = 41° 30'.4$ $\lambda = 81° 41'.5$ W. of Gr.

(Marine Hospital.)

		° ′	
1	1796, September.	2 0 E.	Aug. Porter and Seth Pease; in $\phi = 41° 30'$, $\lambda = 81° 40'$ W. MS. compilation by Charles Whittlesey, March, 1860. In Coast Survey Archives.
2	1830..	1 20	Ahaz Merchant; Prof. E. Loomis's collection, Sill. Jour., vol. xxxix, 1840.
3	1831, August.	1 15	Edwin Foote; MS. compilation by C. Whittlesey, 1860.
4	1834, winter.	0 50	Ahaz Merchant; Prof. E. Loomis's collection, as above.
5	1838, winter.	0 35	Observer and reference as above.
6	1840..	0 19	Prof. E. Loomis; Gen. Sabine in Phil. Trans. Roy. Soc. 1872, contribution xiii. (Misprinted 1° 19′ E, see Dr. C. Davies on "Surveying.")
7	1841, May 1.	0 05.2	J. N. Pillsbury. MS. compilation by C. Whittlesey, 1860.
8	1845...	0 39 E.	From a chart of survey of N. and N. W. Lakes, Top. Eng'rs. Beacon Light in $\phi = 41° 31'$, $\lambda = 81° 41'.5$ W.
9	1859, July 5.	0 46 W.	Lieut. W. P. Smith, Top. Eng'rs; in $\phi = 41° 30'$, $\lambda = 81° 40'$ W. MS. by Ch. Whittlesey; also MS. by W. F. Raynolds, Major of Eng'rs, survey of N. and N. W. Lakes, Dec., 1865.
	1865, May 22.	1 12 E. (?)	MS. by W. F. Raynolds, Maj. of Eng'rs; at east end of pier, W. T. Casgrain, observer. [Value not used.—SCH.]
10	1871, November 9–11.	0 32.6 W.	Edw. Goodfellow, asst. Coast Survey; at Marine Hospital in $\phi = 41° 30'.4$, $\lambda = 81° 41'.5$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
11	1872, June 17, 18.	0 44.9	Capt. A. N. Lee, U. S. Lake Survey; Report of Chief of Eng'rs for 1873.
12	1873, June 16, 17.	0 50.9	Observer and reference as above.
13	1876, October 27, 28.	1 08	A. C. Lamson, in $\phi = 41° 30'$, $\lambda = 81° 43'$. Prof. Papers U. S. Eng'rs No. 24, Washington, 1882.
14	1880, July 9, 10, 12.	1 38.5	J. B. Baylor, U. S. Coast and Geodetic Survey; station of 1871, grounds of the City Hospital.
15	1888, July 23, 24.	2 03.7 W.	J. B. Baylor, asst. C. and Geod. Survey; station of 1871 and 1880. MS. in archives.

GROUP II.—*Collection of Magnetic Declinations, Central Series*—Continued.

16.—OMAHA, NEBR., AND COUNCIL BLUFFS, IOWA.

$\phi=41° 15'.7$ $\lambda=95° 56'.5$ W. of Gr.

(Astron'l station, grounds of High School, Omaha.)

		° ′	
1	1819, September 22.	12 58.8 E.	Major Stephen H. Long, U. S. A.; Expedition to the Rocky Mts., Philadelphia, 1823 (2 volumes). At Engineers' cantonment in $\phi=41° 25'$, $\lambda=96° 00'$ W. [Reduction to Omaha, about −12′, hence decl'n, 12° 47′ E.—SCH.]
2	1869, January 25–27. February 12, 13.	10 42.6	Edw. Goodfellow, asst. Coast Survey; at astron'l station, Omaha; Coast and Geodetic Survey Report for 1881, App. 9.
3	1872, October 31.	10 44.2	Dr. T. C. Hilgard, Bache-Fund observer to National Academy; station as before (1869); Coast and Geodetic Survey Report for 1882, App. 14.
4	1877, October 13–18.	10 22.0	A. Braid, U. S. Coast Survey; station of 1869; Coast and Geodetic Survey Report for 1881, App. 9.
5	1878, August 30.	10 39.7	Dr. T. E. Thorpe; at Council Bluffs, near railway depot in $\phi=41° 15'.3$, $\lambda=95° 52'.4$ W.; Proc. Roy. Soc. No. 200, 1880.
6	1880, October 15, 17.	10 06.2	J. B. Baylor, Coast and Geodetic Survey. Station on grounds of High School as in 1869, 1872, and 1877; Coast and Geodetic Survey Report for 1881, App. 9.
7	1888, September 25, 26.	9 29.6 E.	J. B. Baylor, asst. Coast and Geodetic Survey. Grounds of High School. MS. in archives.

17.—BEAVER, PA.

$\phi=40° 44'$ $\lambda=80° 20'$ W. of Gr.

		° ′	
1	1786..	0 51 E.	Andrew Ellicott, at the Pennsylvania and Ohio line; in $\phi=40° 42'$, $\lambda=80° 31'$. [Reduction to Beaver +8′, derived from an isogonic map for 1790—SCH.]
2	1866, August 7, 8.	0 36.8 W.	F. H. Agnew; at Beaver, in $\phi=40° 43'.7$, $\lambda=80° 20.5'$. MS. communication.
3	1874, August 11.	1 08.2	F. E. Hilgard, observer for Nat. Acad. of Sc. App. 14, C. and Geod. Survey Report for 1882; at Beaver, in $\phi=40° 43'.5$, $\lambda=80° 19'$.
4	1879..	1 31	At the Pa. and Ohio line, in $\phi=40° 43'$, $\lambda=80° 31'$. Report of J. S. Africa, Sec'y of Int. Affairs of Pa. for 1885, Harrisburg, 1886. [Reduction to Beaver +5′—SCH.]
5	1883, September 28.	1 42 W.	At Beaver; observations by county surveyor. Reference as above.

18.—PITTSBURGH, PA.

$\phi=40° 27'.6$ $\lambda=80° 00'.8$ W. of Gr.

(Allegheny Observatory, Allegheny.)

		° ′	
1	1840, August 10.	0 08 W.	Dr. A. D. Bache; at Homewood, in $\phi=40° 28'$, $\lambda=79° 59'.5$ W.; Coast Survey Report for 1862, App. 19.
2	1845, May 3.	0 33.1	Dr. John Locke; in $\phi=40° 26'$, $\lambda=79° 58'$ W.; Coast Survey Report for 1855, p. 304.
3	1878, September 5.	2 21.6	Dr. T. E. Thorpe; at Allegheny, grounds of the astron'l observatory, latitude and longitude as in heading. Proc. Roy. Soc. No. 200, 1880.
4	1884, September 26.	2 41	Hemmings; Annual Report of the Secretary for Internal Affairs of Pa. for 1885, Harrisburg, 1886, p. 16 A, p. 31 A.
5	1885, August 24, 25, 26.	2 55.7 W.	J. B. Baylor, subasst. Coast and Geodetic Survey; at Allegheny, grounds of the Observatory. MS. in archives of Survey.

GROUP II.—*Collection of Magnetic Declinations, Central Series*—Continued.

19.—DENVER, COLO.

$\phi=39° 45'.3$ $\lambda=104° 59'.5$ W. of Gr.

(Coast Survey Astron'l Station.)

		° ′	
1	1866, July.	15 0 E.	John Prince, Surveyor-General of Colorado; in $\phi=39° 45', \lambda=105° 00'$ W. Letter to Office, of July 27, 1866.
2	1872, October 13, 14, 19.	14 44.7	Dr. T. C. Hilgard, Bache-Fund observer to National Academy of Sc.; on Pierce's Block; Coast and Geodetic Survey Report for 1882, App. 14.
3	1873, August 14.	14 42.8	Edw. Smith, asst. Coast Survey; at astron'l station, in $\phi=39° 45'.3$, $\lambda=104° 59'.5$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
4 {	1878, August 8.	14 43.4	Dr. T. E. Thorpe; in Mrs. Craig's garden, $\phi=39° 45'.3$, $\lambda=104° 59'.6$ W.; Proc. Roy. Soc. No. 200, 1880.
	1878, September 3, 4, 5.	14 40.2	J. B. Baylor, U. S. Coast Survey; corner of 17th st. and Broadway. Position as in heading; Coast and Geodetic Survey Report for 1881, App. 9. [Mean, — 14° 41′.8 for 1878.6]
5	1888, October 29, 30.	14 06.1 E.	J. B. Baylor, U. S. C. and Geod. Survey. Station in grounds of State Capitol, a short distance south of station of 1878; in $\phi=39° 45'.3$, $\lambda=104° 59'.5$

20.—MARIETTA, OHIO.

$\phi=39° 25'$ $\lambda=81° 28'$ W. of Gr.

		° ′ E.	
1	1810..	2 36	Jared Mansfield; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838.
2	1823–24.	3 30	Boye; at Parkersburg, W. Va., in $\phi=39° 16'$, $\lambda=81° 34'$ W. Boye's State map of Va. [Reduction to Marietta about $+5'$, hence decl'n $= -3° 25'$—SCH.]
3 {	1838..	{ 1 29	Prof. E. Loomis; reference as above, in $\phi=39° 25'$, $\lambda=81° 26'$ W.
	1838..	1 36	B. E. Stone; near Marietta, in $\phi=39° 31'$, $\lambda=81° 26'$ W. Prof. E. Loomis's collection in Sill. Jour., vol. xxxix, 1840. [The weight ½ is assigned to the mean value.—SCH.]
4	1845, April.	2 25	Henck's Field-book.
5	1850..	1 25	A. D. Bache's table in Gillespie's Treatise on Land Surveying.
6	1864, January 26.	1 17.6 E.	A. T. Mosman, asst. Coast Survey; at Parkersburg, W. Va., in $\phi=39° 16'.0$, $\lambda=81° 34'.2$ W.; Coast and Geodetic Survey Report for 1881, App. 9. [Red'n to Marietta about $+5'$—SCH.]
7	1881, May 30, 31.	0 07.2 W.	J. B. Baylor, Coast and Geodetic Survey; at Parkersburg, station of 1864; reference as before. [Red'n to Marietta about $+5'$—SCH.]

21.—ATHENS, OHIO.

$\phi=39° 19'$ $\lambda=82° 02'$ W. of Gr.

		° ′	
1	1796..	4 03 E.	Public Surveys; Prof. E. Loomis, in Sill. Jour., vol. xxxix, 1840.
2	1806..	4 17	This value depends on the observed declination $-3° 12'$ in 1838, by Pruden, and the observed difference of declination between the years 1806 and 1838 at Gallipolis, by G. Fletcher, viz, $-3° 40' + 2° 35' = -1° 05'$. Reference as above.
3	1838..	3 12	S. B. Pruden. Reference as above.
4	1880, December 3, 4.	0 40.5 E.	J. B. Baylor, C. and Geod. Survey, in $\phi=39° 19'.8$, $\lambda=82 02'$. Appendix 9, Report for 1881.

GROUP II.—*Collection of Magnetic Declinations, Central Series*.—Continued.

22.—CINCINNATI, OHIO.

$\phi=39° 06'.4$ $\lambda=84° 29'.8$ W. of Gr. Old Astronomical Observatory on Mt. Adams.

$\phi=39° 08'.4$ $\lambda=84° 25'.3$ W. of Gr. New Astronomical Observatory on Mt. Lookout.

		° ′	
1	1806..	4 58 E.	Public surveys; Prof. E. Loomis's collection in Sill. Jour., vol. xxxix, 1840, in $\phi=39° 06'$, $\lambda=84° 27'$ W.
2	1810..	5 00	Jared Mansfield; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838, in $\phi=39° 07'$, $\lambda=84° 27'$ W.
3	1840, January 11.	4 46	Dr. John Locke; "Survey of Mineral Lands," Exec. Doc., 1839–40, vol. vi; in $\phi=39° 06'$, $\gamma=84° 27'$ W.
4	1845, April.	4 04	Dr. John Locke; Coast Survey Report for 1855, p. 304; in $\phi=39° 06'$, $\lambda=84° 22'$ W.
5	1880, November 27, 29, 30.	2 14.4	J. B. Baylor, U. S. Coast and Geod. Survey; grounds of new astronomical observatory on Mt. Lookout; Coast and Geodetic Survey Report for 1881, App. 9.
6	1888, July 28, 30.	1 58.0 E.	J. B. Baylor, asst. C. and Geod. Survey. Close to station of 1880. MS. in archives.

23.—ST. LOUIS, MO.

$\phi=38° 38'.0$ $\lambda=90° 12'.2$ W. of Gr.

(Washington University.)

		° ′	
	1819, June 17.	10 47.6 E.	Maj. S. H. Long; at St. Louis, in $\phi=38° 36'$, $\lambda=90° 06'$ W. [Longitude as given, about 5′ too small.—SCH.] Account of an expedition from Pittsburg to the Rocky Mts. in 1819 and 1820, by Maj. S. H. Long, Philadelphia, 1823. [Not used; supposed to be in error about $2\frac{1}{3}°$—SCH.]
1	1835..	8 49	Col. Nicolls; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838.
	1838..	7 45	De Ward, surveyor; on city commons. Letter of Thos. Featherson, of June 18, 1877; communicated by W. Eimbeck, asst. Coast Survey. [Not used.—SCH.]
2	1855..	8 00	Colton's General Atlas, New York, 1873.
	1856, October 31.	6 23.1	Karl Friesach; Berichte der Kais. Akad. der Wiss., Vienna, vol. xxix, 1858. [Not used; supposed to be locally affected.—SCH.]
3	1872, June, July, and August.	6 37.5	Dr. T. C. Hilgard, Bache-Fund observer to National Academy. Two stations, south and west of court-house; first on Compton Hill, in $\phi=38° 37'.1$, $\lambda=90° 14'.0$ W., decl'n 6° 35′.2 E., and second near City Hospital, in $\phi=38° 36'.5$, $\lambda=90° 12'.7$ W., decl'n 6° 39′.9 E. Coast and Geodetic Survey Report for 1882, App. 14. [Result at a third station, 6° 48′.9 E., in field adjoining first position, not used.—SCH.]
4	1877, June.	6 30.5	Thomas Featherson, deputy county surveyor St. Louis Co.; from comparisons of 17 old lines run in the city commons in 1838 by De Ward, surveyor; communicated by W. Eimbeck, asst. Coast Survey; annual change since 1838 supposed to have been +1′.91
5	1878, August 14, 15.	6 33.7	Prof. F. E. Nipher, Washington University. Observations in vacant square, S. E. corner of Garrison ave. and Dickson street; Trans. St. Louis Acad. of Sciences. [The instrument was loaned by the Coast Survey.—SCH.]
6	1879, September.	6 13.3 E.	Observer as before; at corner of Garrison ave. and Glasgow place; communicated to office Oct. 14, 1879.

Group II.—*Collection of Magnetic Declinations, Central Series*—Continued.

ST. LOUIS, MO.—Continued.

		° ′	
7	1886, October 3, 4, 5, 6.	6 10.6 E.	C. H. Sinclair, asst. Coast and Geodetic Survey; near N. W. corner of Tower Grove Park, St. Louis, in φ=38° 36′.7, λ=90° 15′.4 W.; MS. in archives of Survey.

The expression deduced for St. Louis is still uncertain.

24.—NASHVILLE, TENN.

ϕ=36° 08′.9 λ=86° 48′.2 W. of Gr.

(Vanderbilt University.)

		° ′	
1	1829..	6 50 E.	Prof. Hamilton; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838, in ϕ=36° 10′, λ=86° 49′ W.
2	1835..	7 07	Prof. Hamilton; reference as above. [w=¼—Sch.]
3	1877, December 5, 6, 7.	5 14.9	And. Braid, U. S. Coast Survey; grounds of Vanderbilt University, in ϕ=36° 08′.9, λ=86° 48′.2 W.; Coast and Geodetic Survey Report for 1881, App. 9.
4	1888, August 7, 8.	4 31.0 E.	J. B. Baylor, asst. C. and Geod. Survey. Station near that of 1877 and west of the central building of the university; ϕ=36° 08′.9, λ=86° 48′.3. MS. in archives.

25.—FLORENCE, ALA.

ϕ=34° 47′.2 λ=87° 41′.5 W. of Gr.

(Coast Survey Station.)

		° ′	
1	1818..	6 35 E.	J. H. Weakly; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838; position assigned, ϕ=34° 50′, λ=87° 47′ W.
2	1835..	6 28	Observer and reference as before.
3	1865, April 17.	5 24	A. T. Mosman, asst. Coast Survey; Coast and Geodetic Survey Report for 1881, App. 9, in ϕ=34° 47′.2, λ=87° 41′.7 W., near railway bridge.
4	1875, May 29.	5 14.4	F. E. Hilgard, Bache-Fund observer to National Academy, in ϕ=43° 47′, λ=87° 42′ W.; Coast and Geodetic Survey Report for 1882, App. 14.
5	1881, September 5, 6.	4 37.8 E.	J. B. Baylor; Coast and Geodetic Survey; grounds of College for Females, in ϕ=34° 47′, λ=87° 43′ W.; Coast and Geodetic Survey Report for 1881, App. 9.

NATCHEZ, MISS.

ϕ = 31° 33′.5 λ = 91° 24′.0 W. of Gr.

(Coast Survey Astronomical Station.)

		° ′	
1	1802..	9 0 E.	Dunbar; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838; in ϕ=31° 34′, λ=91° 25′ W.
2	1872, April 21, 22.	7 14.8	Dr. T. C. Hilgard, Bache-Fund observer to National Acad.; in ϕ=31° 34′, λ=91° 24′ W.; Coast and Geodetic Survey Report for 1882, App. 14.
3	1878–'79.	7 23 E.	W. H. Dennis, asst. Coast Survey; in ϕ=31° 33′.5, λ=91° 24′.1 W. Marked on MS. triangulation sketch. [No satisfactory result can be had from these few observations.—Sch.]

GROUP II.—*Collection of Magnetic Declinations, Central Series*—Continued.

26.—MOBILE, ALA.

$\phi=30° 41'.4$ $\lambda=88° 02'.5$ W. of Gr.

(Episcopal Church.)

		° ′	
	1809..	8 10 E.	J. H. Weakly; in $\phi=30° 40'$, $\lambda=88° 11'$ W.; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838. [Not used.—SCH.]
1	1814..	6 30	Kent; Encycl. Britan., 7th edition, 1842. For Mobile Bay; in $\phi=30° 13'$, $\lambda=88° 21'$ W. [Longitude defective.—SCH.]
2	1835..	7 12	J. H. Weakly; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838.
3	1840..	7 05	Chart of Mobile Bay by E. and G. W. Blunt; Coast Survey Report for 1845, p. 42.
4	1843..	6 56	Commander L. M. Powell, U. S. N. (in an official report). At Mobile Pt. Light, $\phi=30° 13'.8$, $\lambda=88° 01'.5$ W.; Coast Survey Report for 1855, p. 323. [Reduction to Mobile inappreciable.—SCH.]
5	1847, May 21–30.	7 04.1	R. H. Fauntleroy, asst. Coast Survey; at Fort Morgan, in $\phi=30° 13'.9$, $\lambda=88° 01'.2$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
6	1857, February 14–18.	6 52.2	Edw. Goodfellow, asst. Coast Survey; in Public Square, Mobile, 210 feet north of astronom'l station, in $\phi=30° 41'.6$, $\lambda=88° 02'.6$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
7	1875, May 27.	6 07.0	J. M. Poole, Bache-Fund observer to National Academy; in part of city known as Summerville, in $\phi=30° 42'$, $\lambda=88° 03'$ W.; Coast and Geodetic Survey Report for 1882, App. 14.
8	1883, March 12.	5 17 E.	Lieut. E. S. Prime, U. S. S. Yantic; in $\phi=30° 08'$, $\lambda=88° 01'$ W.; Naval Professional Papers No. 19, Washington, 1886. [Reduction to Mobile inappreciable.—SCH.]

PENSACOLA, FLA.*

$\phi=30° 20'.8$ $\lambda=87° 18'.3$ W. of Gr.

(Light-house.)

		° ′	
1	1763..	4½ E.	From an English plan of Pensacola.†
2	1775..	4½	Des Barres's Atlantic Neptune, London, 1781; Pensacola Bay, inside the harbor. [$\phi=30° 20'$, $\lambda=87° 16'$—SCH.]
3	1807..	7 50	V. S. Pintado.†
4	1817..	8 45	V. S. Pintado.†
5	1835..	6 10	Pensacola, by a Navy officer, Sill. Jour., vol. xxxiv, 1838. In $\phi=30° 24'$, $\lambda=87° 12'$. Prof. E. Loomis gives 6° 00′ E.
6	1843..	6 54	Navy-yard; Commander L. M. Powell, U. S. N.
7	1858, June 21.	6 47.3	Public square, astronomical station; J. G. Oltmanns, subassist. Coast Survey. In $\phi=30° 24'.6$, $\lambda=87° 12°.9$ Rep. for 1881, App. 9.
8	1861, January 8, 9.	6 42.2	At Barkley Point, in $\phi=30° 24'.6$, $\lambda=87° 12'.5$; G. W. Dean, asst. Coast Survey. Report for 1881, App. 9.
9	1880, January 1.	5 20	W. H. Davison, city engineer, Pensacola.†
10	1890, March.	4 55 E.	W. H. Davison.† "I think the present variation here is a trifle under 5° E." Letter of March 26, 1890. Mr. Davison also remarks: "8° 45′ is the highest variation of which there is any record in our archives."

* This station was inserted while the paper was going through the press. [April 1890.]

† Information received from W. H. Davison, city engineer, Pensacola, letter of March 26, 1890.

GROUP II.—*Collection of Magnetic Declinations, Central Series*—Continued.

27.—NEW ORLEANS, LA.

$\phi=29° 57'.2$ $\lambda=90° 03'.9$ W. of Gr.

(Custom House..)

		° ′	
1	1700..	3 E.	An auxiliary value depending on observations about this period; see C. and Geod. Survey Bulletin No. 6.
		2½	Edm. Halley's isogonic chart gives 2½°; see reproduction of chart in Greenwich observations for 1869. [Adopted mean, —2°.75—SCH.]
2	1720..	2	Father Laval; Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838. [To this value the weight ½ is given.—SCH.]
3	1750..	4 36	An auxiliary value depending on observations about this period; see C. and Geod. Survey Bulletin No. 6.
	1768..	7 50	Gauld; Gauld's survey of the Delta, near Pass à l'Outre. [Reduction to New Orleans, add 10′. Not used.—SCH.]
4	1796..	5 06	A. G. Blanchard, city surveyor; change from 1796 to 1870, 2° east.
5	1806..	8 03	Lason; from 372 observations. Prof. E. Loomis's collection in Sill. Jour., vol. xxxiv, 1838.
6	1840..	8 20	From information recorded in General Land Office.
7	1856, December 28.	8 00	Karl Friesach; Berichte der Kais. Akad. der Wiss., Vienna, vol. xxix, 1858.
8	1858, April 6, 7.	7 51.5	G. W. Dean, asst. Coast Survey; near Canal and Basin sts., in $\phi=29° 57'.4$, $\lambda=90° 04'.4$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
9	1870..	7 06	M. J. Thompson, State engineer.
10	1872, February 10–15.	6 39.6	Dr. T. C. Hilgard, Bache-Fund observer to National Academy; observations at City Park, 6° 39′.8 E.; at Fair Grounds, 6° 39′.5 E. Position of City Park in $\phi=29° 55'.6$, $\lambda=90° 07'.8$ W.; position of Fair Grounds in $\phi=29° 59'.1$, $\lambda=90° 04'.8$ W. Coast and Geodetic Survey Report for 1881, App. 9, and for 1882, App. 14.
11	1880, March 24, 25.	6 27.6 E.	J. B. Baylor, U. S. Coast and Geodetic Survey; at Fair Grounds; Coast and Geodetic Survey Report for 1881, App. 9.

28.—SAN ANTONIO, TEX.

$\phi=29° 25'.4$ $\lambda=98° 29'.3$ W. of Gr.

(Arsenal Grounds.)

		° ′	
1	1825..	10 30 E.	Land Office record at San Antonio; communicated by Mr. J. B. Baylor.
2	1836..	9 45	
3	1874..	9 30	
4	1878, June 10, 11, 12.	9 22.3 E.	J. B. Baylor, U. S. Coast and Geodetic Survey; in Arsenal Grounds; position as in heading; Coast and Geodetic Survey Report for 1881, App. 9.

GROUP II.—*Collection of Magnetic Declinations, Central Series*—Continued.

29.—KEY WEST, FLA.

$\phi=24° 33'.5$ $\lambda=81° 48'.5$ W. of Gr.

(Tift's Observatory.)

		° ′	
	1700.0	5 E.	Edm. Halley's isogonic chart or Tabula Nautica Variationum Magneticarum Index, &c., anno 1700, reproduced in Greenwich observations for 1869. [Probably 1° in error; see values for Havana and Kingston; not used.—SCH.]
1	1750..	5.6	An auxiliary value depending on observations about this period; see C. and Geod. Survey Bulletin No. 6. [$w=½$—SCH.]
2	1829, February.	6 25	W. A. Whitehead; from a map of Florida by the Topographical Engineers, 1846.
3	1843..	6 02	Report of Commander L. M. Powell, U. S. N.; at Custom-House.
4	1849, August 19–21.	5 28.8	J. E. Hilgard, asst. Coast Survey; at Sand Key, in $\phi=24° 27'.2$, $\lambda=81° 53'.1$ W.; Coast Survey Report for 1854, p. 145.
5	1860, February, March, June, and December.	4 46.6	Prof. W. P. Trowbridge, asst. Coast Survey; at magnetic observatory, in $\phi=24° 33'.1$, $\lambda=81° 48'.5$ W. W. P. Trowbridge and S. Walker, observers. Coast and Geodetic Survey Report for 1881, App. 9.
6	1861, February, March, and April.	4 44.5	S. Walker, observer; at magnetic observatory. Means of monthly results and corrected for diurnal variation. In 1861 the observers were S. Walker and J. G. Oltmanns; in 1862, Walker, Oltmanns, and F. F. Nes; reference as before.
7	1862, May to December, inclusive.	4 39.9	
8	1863, January to December, inclusive.	4 36.8	
9	1864, January to December, inclusive.	4 33.9	
10	1865, January to December, inclusive.	4 31.5	
11	1866, January to April, inclusive.	4 29.8	
12	1879, March 24, 25, 26.	3 33.9	Lieut. S. M. Ackley, U. S. N., asst. Coast and Geod'c Survey; grounds of Army Hospital, in $\phi=24° 33'.3$, $\lambda=81° 47'.9$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
13	1884, April 4.	3 00	Lieut. C. Belknap, U. S. S. Vandalia; in $\phi=24° 27'$, $\lambda=81° 48'$ W.; Naval Professional Papers No. 19, Washington, 1886. [Red'n to Key West inappreciable.—SCH.]
13	1884, May 10.	2 49	Lieut. R. B. Peck, U. S. S. Swatara; in $\phi=24° 25'$, $\lambda=81° 46'$ W.; reference as before. [Reduction to Key West inappreciable; mean, —2° 54'.5; $w=½$—SCH.]
14	1887, February 1, 2, 3.	3 19.8 E.	J. B. Baylor, asst. C. and Geod. Survey at the grounds of the Army Hospital. Position as in 1879.

30.—HAVANA, CUBA.

$\phi=23° 09'.3$ $\lambda=82° 21'.5$ W. of Gr.

(Morro Light.)

		° ′	
	1700.0	6 E.	Edm. Halley's isogonic chart for 1700; reproduced in Greenwich observations for 1869. [Not used.—SCH.]
1	1726..	4 24 E.	Mathews; in $\phi=23° 02'$, $\lambda=81° 44'$ W.; Encycl. Britan., 1848. [Rough reduction to Havana +10'; hence 4° 34' E.—SCH.]

GROUP II.—*Collection of Magnetic Declinations, Central Series, etc.*—Continued.

HAVANA, CUBA—Continued.

		° ′	
2	1732, March and April.	4 30 E.	J. Harris; off Havana, in $\phi=23°08'$, $\lambda=82°$ 32′ W.; Phil. Trans. Roy. Soc., vol. vii (abridged), 1724–34; also Encycl. Metrop., 1848.
3	1815..	7 00	Encycl. Brit., 7th edition, 1842.
4	1816, August.	5 30	Bentley; reference as before.
5	1833.0	6 50	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., 1833, p. I. [Supposed to be about 1° too great; see Key West and Kingston series; used temporarily 5° 50′ E.—SCH.]
6	1857, January 28.	5 15	Karl Friesach; Imp. Acad. of Sc., Vienna, vol. xxix, 1858.
7	1858..	5 45	From a map of Cuba, 1860.
8	1879, March 13, 14, 15.	3 53.8	Lieut. S. M. Ackley, U. S. N., asst. Coast and Geodetic Survey; at the College de Belen. [Annual change at the Colegio de Belen, according to Padre B. Viñes, S. J., director of observatory, 4′.5, decreasing for several years past. Letter of Lieut. Ackley of Mch. 21, 1879. The position of the Morro Light, as given in heading, is that determined by Lieut. Comdr. F. M. Green, U. S. N., and that of the Colegio de Belen is according to Director Viñes (1885) in $\phi=23°$ 08′.2, $\lambda=82°$ 22′.1 W.—SCH.]
9	1884, April.	2 34	Lieut. C. Belknap, U. S. S. Vandalia; in $\phi=23°$ 02′, $\lambda=81°$ 43′ W. Naval Professional Papers No. 19, Washington, 1886. [Reduced to Havana, 2° 44′ E.; the weight 1½ is temporarily assigned to this value.—SCH.]
10	1885, November 5, 6, 14.	3 41	Benito Viñes, S. J., Real Colegio de Belen. Observaciones magneticas y meteorologicas del Real Colegio de Belen. Habana, 1886.
11	1886, December 21, 4 p. m.	3 33.5 E.	Reference as above. [Corrected for diurnal variation, —3°.58—SCH.]

31.—KINGSTON, PORT ROYAL, JAMAICA.

$\phi=17°$ 55′.9 $\lambda=76°$ 50′.6 W. of Gr.

(Port Royal Flagstaff.)

		° ′	
	1660..	6 30 E.	Declination in Jamaica according to J. Robertson; Phil. Trans. Roy. Soc., 1806. [Not used.—SCH.]
	1700..	6 30	According to Mountain's chart constructed in the year 1700 from Dr. Halley's tables; Long's History of Jamaica. [Halley's Tabula Nautica gives 7° E. for 1700. Not used.—SCH.]
1	1726, September 12.	4 31	Mathews, at Port Royal. Magnetismus der Erde, Hansteen, 1819.
2	1732, March and April.	6 02.5	J. Harris, at Black River; Phil. Trans. Roy. Soc., 1733. [Mean value of 6° and 6° 5′ E.—SCH.]
3	1789 to 1793. 1791 to 1792.	6 50 6 45	J. Leard; Chart of Port Royal.
4	1806..	6 30	J. Robertson; Phil. Trans. Roy. Soc., 1806. The variation in Jamaica said to have been constant for 130 to 140 years.
5	1819.. 1821..	4 50 4 50	De Mackau; in $\phi=17°$ 55′, $\lambda=76°$ 09′ W. De Mayne; in $\phi=17°$ 55′, $\lambda=76°$ 53′ W. Becquerel's Traité du Magnétisme, Paris, 1846.
6	1822..	4 54	Owen; Becquerel as above.
7	1832..	5 13	Foster; Becquerel as above.
8	1833(?).	4 40 E.	From a map of Kingston, date of 1854.

GROUP II.—*Collection of Magnetic Declinations, Central Series*—Continued.

KINGSTON, PORT ROYAL, JAMAICA—*Continued.*

		° ′		
	1833.0	6 30	E.	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., 1833. [Not used; value supposed to be about 1° too great; see Havana and Key West series.—SCH.]
9	1837, October.	4 18		Milne; in $\phi=17° 56'$, $\lambda=76° 51'$ W. Lieut. Col. Edw. Sabine's contributions to Terr. Mag. No. ix; Phil. Trans. Roy. Soc., 1849, part II.
10	1847, April.	3 40		Barnett; in $\phi=17° 56'$, $\lambda=76° 51'$ W.; reference as before.
11	1857, March 2.	3 40		Karl Freisach; Imp. Acad. of Sci., Vienna, vol. xxix, 1858.
	1866..	4 57		British Admiralty Chart of Jamaica, No. 446; variation in 1866, nearly stationary. [Not used.—SCH.]
12	1875..	4 00		British Admiralty Chart, No. 456; Port Royal and Kingston Harbor; annual decrease 2′.
13	1876..	3 35		Brit. Admiralty Chart, No. 762; West India Islands and Caribbean Sea.
14	1880..	3 06		Brit. Admiralty Chart; curves of equal magnetic variation, 1880.
15	1884, February 8.	2 20	E.	Lieut. R. B. Peck, U. S. S. Swatara; in $\phi=17° 58'$, $\lambda=76° 48'$ W.; Naval Professional Papers, No. 19, Washington, 1886.

32.—BARBADOS, CARIBBEE ISLANDS.

$\phi=+13° 05'.7$ $\lambda=59° 37'.3$ W. of Gr.

(Bridgetown, Rickett's battery.)

		° ′		
1	1726, June 26, 28; Oct. 23.	4 24	E.	Mathews. "Magnetismus der Erde," C. Hansteen, 1819, and Encyclopædia Metropolitana, 1848. At Carlisle Bay.
	1726, June 29.	3 29		Hansteen's "Magnetismus der Erde," 1819; at Lambert Point. [Mean, —3° 55′—SCH.]
2	1760, May 28, 31.	4 30		Ross; reference as above.
3	1761, May 4.	3 47		Ross; reference as above.
4	1833..	1 29		Phillips. Sir Edward Sabine in Cont's xiv, Phil. Trans. Roy. Soc., 1875.
5	1839..	1 13		Milne; reference as before.
6	1846..	1 27		Schomburgh; reference as before.
7	1871..	0 35	E.	Staff Com. Parsons, Brit. Adm'y chart No. 2485, edition of 1873. Magnetic declination decreasing about 2′ annually.
8	1884, April 24.	1 50	W.	Lieut. Hanford, U. S. S. Pensacola, in $\phi=13° 19'$, $\lambda=59° 41'$ W. U. S. Nav. Prof. Papers No. 19, Washington, 1886. [Approximate reduction to Barbados —15′; hence declination +1°.58; $w=\frac{1}{2}$—SCH.]

33.—PANAMA, NEW GRANADA.

$\phi=8° 57'.1$ $\lambda=79° 32'.2$ W. of Gr.

(Cathedral.)

		° ′		
	1700.0	10	E.	Approximate value; Edm. Halley's isogonic chart for 1700, reproduced in Greenwich observations of 1869. [Not used.—SCH.]
1	1775, November.	7 49		Encycl. Brit., 7th edition, 1842.
2	1790, October 3.	7 49	E.	Don A. Malaspina; Berliner Astronomisches Jahrbuch, Vol. 53, for 1828, p. 188.

GROUP II.—*Collection of Magnetic Declinations, Central Series*—Continued.

PANAMA, NEW GRANADA—Continued.

		° ′		
	1791, December.	7 49	E.	Encycl. Brit., 7th edition, 1842. [Probably same authority as for preceding date; not used.—SCH.]
3	1802..	8 00		Encycl. Brit., 7th edition, 1842.
4	1822..	7 00		Hall; in ϕ=8° 58′, λ=79° 21′ W. Becquerel's Traité du Magnétisme, Paris, 1846. [The weight ½ is assigned to this value.—SCH.]
5	1837..	7 02		Sir Edw. Belcher; in ϕ=8° 57′, λ=79° 29′ W. Phil. Trans. Roy. Soc., 1843.
6 {	1849..	7 15		Hughes; Brit. Admiralty chart.
	1849..	6 55		Major W. H. Emory, Mexican Boundary Commissioner; in ϕ=8° 57′, λ=79° 29′ W.; Coast Survey Report for 1856, p. 223. [Mean, 7° 5′ E.—SCH.]
7	1858..	6 17		Karl Friesach; in ϕ=8° 57′, λ=79° 31′ W. Sir Edw. Sabine's Contributions to Terr. Mag., in Phil. Trans. Roy. Soc. for 1875.
8	1866, May 14.	5 56		Prof. W. Harkness, U. S. N.; in ϕ=8° 55′, λ=79° 30′.5. Smithsonian Contributions to Knowledge, No. 239, Washington, 1873.
9	1873, December 25.	6 57		From log-books of the Benicia and Richmond; Hydrographic Office, Navy Dept., Washington; in ϕ=7° 26′, λ=79° 54′ W., off Point Mala. [Reduced to Panama —38′, hence decl'n 6° 19′ E.; weight ½.—SCH.]
10	1880..	5 24		Brit. Admiralty Chart; curves of equal magnetic variation, 1880.
11	1883, February 22.	5 02		Annales du Bureau des Longitudes, tome 3, Paris, 1883, p. 396–7. Promenade near the Cathedral, in ϕ=8° 57′, λ=79° 31′ W.
12	1884, March 20.	5 23	E.	Lieut. C. Belknap, U. S. S. Vandalia; in ϕ=9° 22′, λ=79° 54′ W. Naval Prof. Papers, No. 19, Washington, 1886. [Reduction to Panama inappreciable.—SCH.]

Results for Group II.—Magnetic stations mainly in the central part of the United States between the Appalachian and Rocky Mountain ranges, with additions in British North America, Canada, the West Indies, and Central America.

The letter D in the last column of the table stands for declination, a plus sign indicating west declination, a minus sign east declination. The letter m stands for t—1850.0, or for the difference in time, expressed in years and fraction of a year, for any time t and the middle of the century; it is to be taken within the range of observation at any station.

No.	Name of station and State.	Latitude.	West longitude.	The magnetic declination expressed as a function of time.
		° ′	° ′	° ° °
1	York Factory, British North America.	56 59.9	92 26	$D=+7.34+16.03 \sin(1.10\,m-97.9)$
2	Fort Albany, British North America.	52 22	82 38	$D=+15.78+6.95 \sin(1.20\,m-99.6)$*
3	Duluth, Minn., and	46 45.5	92 04.5	$D=-7.70+2.41 \sin(1.4\,m-120.0)$*
	Superior City, Wis.	46 39.9	92 04.2	
4	Sault de Ste. Marie, Mich.	46 29.9	84 20.1	$D=+1.54+2.70 \sin(1.45\,m-58.5)$
5	Pierrepont Manor, N. Y.	43 44.5	76 03.0	$D=+5.95+3.78 \sin(1.4\,m-22.2)$
6	Toronto, Canada.	43 39.4	79 23.5	$D=+3.60+2.82 \sin(1.4\,m-44.7)$ $+0.09 \sin(9.3\,m+136)$ $+0.08 \sin(19\,m+247)$
7	Grand Haven, Mich.	43 05.2	86 12.6	$D=-4.95+0.0380\,m+0.00120\,m^2$
8	Milwaukee, Wis.	43 02.5	87 54.2	$D=-4.12+3.60 \sin(1.45\,m-64.5)$*
9	Buffalo, N. Y,	42 52.8	78 53.5	$D=+3.66+3.47 \sin(1.4\,m-27.8)$
10	Detroit, Mich.	42 20.0	83 03.0	$D=-0.97+2.21 \sin(1.5\,m-15.3)$
11	Ypsilanti, Mich.	42 14	83 38	$D=-1.20+3.40 \sin(1.40\,m-4.1)$
12	Erie, Pa.	42 07.8	80 05.4	$D=+2.17+2.69 \sin(1.5\,m-27.3)$
13	Chicago, Ill.	41 50.0	87 36.8	$D=-3.77+2.48 \sin(1.45\,m-62.5)$
14	Michigan City, Ind.	41 43.4	86 54.4	$D=-3.23+2.42 \sin(1.4\,m-48.0)$
15	Cleveland, Ohio.	41 30.4	81 41.5	$D=+0.47+2.39 \sin(1.30\,m-14.8)$
16	Omaha, Nebr.	41 15.7	95 56.5	$D=-9.30+3.34 \sin(1.30\,m-54.7)$
17	Beaver, Pa.	40 44	80 20	$D=+1.41+2.72 \sin(1.40\,m-39.6)$
18	Pittsburgh, Pa.	40 27.6	80 00.8	$D=+1.85+2.45 \sin(1.45\,m-28.4)$
19	Denver, Colo.	39 45.3	104 59.5	$D=-15.30+0.011\,m+0.0005\,m^2$
20	Marietta, Ohio.	39 25	81 28	$D=+0.02+2.89 \sin(1.4\,m-40.5)$
21	Athens, Ohio.	39 19	82 02	$D=-1.51+2.63 \sin(1.4\,m-24.7)$
22	Cincinnati, Ohio.	39 08.4	84 25.3	$D=-2.59+2.43 \sin(1.42\,m-37.9)$
23	Saint Louis, Mo.	38 38.0	90 12.2	$D=-5.91+3.00 \sin(1.40\,m-51.1)$*
24	Nashville, Tenn.	36 08.9	86 48.2	$D=-3.57+3.33 \sin(1.35\,m-68.5)$*
25	Florence, Ala.	34 47.2	87 41.5	$D=-4.25+2.33 \sin(1.3\,m-52.8)$
26	Mobile, Ala.	30 41.4	88 02.5	$D=-4.38+2.69 \sin(1.45\,m-76.4)$
--	Pensacola, Fla.	30 20.8	87 18.3	$D=-4.40+3.16 \sin(1.4\,m-59.4)$
27	New Orleans, La.	29 57.2	90 03.9	$D=-5.20+2.98 \sin(1.40\,m-69.8)$
28	San Antonio, Tex.	29 25.4	98 29.3	$D=-7.40+2.88 \sin(1.35\,m-81.8)$*
29	Key West, Fla.	24 33.5	81 48.5	$D=-4.31+2.86 \sin(1.30\,m-23.9)$
30	Havana, Cuba.	23 09.3	82 21.5	$D=-4.25+2.74 \sin(1.25\,m-23.3)$*
31	Kingston, Port Royal, Jamaica.	17 55.9	76 50.6	$D=-3.81+2.39 \sin(1.10\,m-10.6)$
32	Barbados, Caribbee Islands.	13 05.7	59 37.3	$D=-1.38+2.84 \sin(1.10\,m+09.4)$
33	Panama, New Granada.	8 57.1	79 32.2	$D=-5.66+2.22 \sin(1.10\,m-27.8)$

* Expression very uncertain.

GROUP II.—*Comparison of observed and computed Magnetic Declinations.*

1.—YORK FACTORY, BRIT. N. A.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1725.5	+19.00	+20.43	—1.43
1787.5	+ 5.00	+ 3.68	+1.32
1819.7	— 6.00	— 4.69	—1.31
1843.6	9.01	8.12	—0.89
1857.6	7.62	8.66	+1.04
1879.5	7.00	7.22	+0.22
1884.7	— 6.66	— 6.48	—0.18

2.—FORT ALBANY, BRIT. N. A.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1668.5	+19.25	+20.48	—1.23
1730.6	23.00	21.97	+1.03
1774.7	17.00	16.99	+0.01
1842.5	7.50	9.19	—1.69
1880.0	+10.50	+ 9.56	+0.94

3.—DULUTH, MINN., AND SUPERIOR CITY, WIS.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1859.5	— 9.42	— 10.01	+ .59
1861.5	10.20	10.04	— .16
1870.7	10.50	10.11	— .39
1871.5	10.67	10.11	— .56
1880.6	— 9.76	—10.05	+ .29

4.—SAULT DE STE. MARIE, MICH.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1790.5	0.00	+ 0.01	— .01
1843.5	— 1.13	— 0.96	— .17
1844.8	1.02	0.93	— .09
1845.5	0.77	0.91	+ .14
1846.8	0.67	0.87	+ .20
1856.7	— 0.54	— 0.49	— .05
1873.6	+ 0.08	+ 0.43	— .35
1879.8	1.02	0.82	+ .20
1880.6	+ 0.99	+ 0.88	+ .11

5.—PIERREPONT MANOR, N. Y.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1823.7	+ 2.27	+ 2.71	—0.44
1847.7	4.38	4.33	+0.05
1856.9	+ 5.17	+ 5.13	+0.04

PIERREPONT MANOR, N. Y.—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1860.5	+ 5.60	+ 5.45	+0.15
1863.5	5.73	5.73	00
1864.3	5.83	5.81	+ .02
1865.4	6.00	5.91	+ .09
1866.7	6.25	6.03	+ .22
1867.6	6.17	6.11	+ .06
1868.4	6.17	6.19	— .02
1869.4	6.30	6.28	+ .02
1870.5	6.06	6.38	— .32
1874.8	+ 6.55	+ 6.77	— .22

6.—TORONTO, CANADA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1840.1	+ 1.45	+ 1.36	+ .09
1841.5	1.24	1.40	— .16
1842.5	1.32	1.45	— .13
1845.5	1.48	1.52	— .04
1846.5	1.51	1.54	— .03
1847.5	1.55	1.56	— .01
1848.5	1.59	1.57	+ .02
1849.5	1.62	1.59	+ .03
1850.5	1.64	1.62	+ .02
1851.5	1.68	1.66	+ .02
1853.5	1.77	1.76	+ .01
1854.5	1.80	1.82	— .02
1855.5	1.87	1.88	— .01
1856.5	1.94	1.95	— .01
1857.5	2.01	2.02	— .01
1858.5	2.07	2.08	— .01
1859.5	2.12	2.14	— .02
1860.5	2.18	2.20	— .02
1861.5	2.24	2.25	— .01
1862.5	2.26	2.29	— .03
1863.5	2.32	2.33	— .01
1864.5	2.36	2.37	— .01
1865.5	2.41	2.41	.00
1866.5	2.46	2.45	+ .01
1867.5	2.50	2.50	.00
1868.5	2.55	2.55	.00
1869.5	2.62	2.62	.00
1870.5	2.70	2.69	+ .01
1871.5	2.80	2.78	+ .02
1872.5	+ 2.88	+ 2.88	.00

TORONTO, CANADA.—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1873.5	+ 2.97	+ 2.98	— .01
1874.5	3.07	3.09	— .02
1875.5	3.19	3.20	— .01
1876.5	3.31	3.30	+ .01
1877.5	3.41	3.41	.00
1878.5	3.52	3.50	+ .02
1879.5	3.62	3.58	+ .04
1880.8	3.68	3.67	+ .01
1884.6	+ 3.95	+ 3.87	+ .08

7.—GRAND HAVEN, MICH.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1825.5	— 5.25	— 5.16	— .09
1837.5	5.08	5.24	+ .16
1859.6	4.40	4.47	+ .07
1865.6	4.25	4.07	— .18
1873.7	3.47	3.38	— .09
1880.5	— 2.43	— 2.68	+ .25

8.—MILWAUKEE, MICH.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1859.6	— 6.34	— 6.90	+ .56
1871.4	6.72	6.11	— .61
1873.6	6.37	5.94	— .43
1882.7	4.92	5.18	+ .26
1888.7	— 4.37	— 4.65	+ .28

9.—BUFFALO, N. Y.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1797.5	0.00	+ 0.26	— .26
1798.5	+ 0.50	0.24	+ .26
1837.5	1.42	1.19	+ .23
1839.5	1.25	1.31	— .06
1845.5	1.42	1.71	— .29
1859.5	2.94	2.79	+ .15
1872.5	3.87	3.89	— .02
1873.5	3.97	3.97	.00
1885.7	+ 5.07	+ 4.98	+ .09

10.—DETROIT, MICH.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1810.5	— 2.80	— 3.10	+ .30
1822.5	— 3.22	— 2.82	— .40

GROUP II.—*Comparison of observed and computed Magnetic Declinations*—Continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
DETROIT, MICH.—continued.			
	°	°	°
1828.5	— 2.83	— 2.60	— .23
1835.5	2.17	2.30	+ .13
1840.5	1.97	2.06	+ .09
1859.3	0.70	1.01	+ .31
1865.5	0.67	0.66	— .01
1872.4	0.42	0.28	— .14
1873.4	0.29	0.22	— .07
1876.4	— 0.08	— 0.06	— .02
1885.7	+ 0.52	+ 0.40	+ .12
11.—YPSILANTI, MICH.			
1815.5	— 4.00	— 3.89	— .11
1825.5	3.27	3.31	+ .04
1832.5	2.67	2.83	+ .16
1838.5	2.42	2.37	— .05
1851.5	1.20	1.31	+ .11
1855.0	1.00	1.03	+ .03
1859.1	0.75	0.69	— .06
1860.4	0.63	0.58	— .05
1863.5	— 0.42	— 0.34	— .08
1875.9	+ 0.50	+ 0.61	— .11
1878.5	0.75	0.79	— .04
1881.2	1.00	0.97	+ .03
1885.6	1.22	1.23	— .01
1887.3	1.42	1.33	+ .09
1888.6	+ 1.50	+ 1.40	+ .10
12.—ERIE, PA.			
1786.8	+ 0.53	— 0.11	+ .64
1793.5	— 0.70	0.32	— .38
1795.5	— 0.72	— 0.37	— .35
1841.6	+ 0.50	+ 0.45	+ .05
1855.5	1.55	1.29	+ .26
1859.4	1.65	1.56	+ .09
1862.6	1.53	1.78	— .25
1867.3	2.22	2.11	+ .11
1873.6	2.31	2.55	— .24
1876.5	2.83	2.75	+ .08
1877.9	3.00	2.84	+ .16
1883.9	3.33	3.24	+ .09
1885.7	+ 3.14	+ 3.36	— .22

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
13.—CHICAGO, ILL.			
	°	°	°
1823.5	— 6.20	— 6.21	+ .01
1857.6	5.77	5.71	— .06
1878.7	4.55	4.66	+ .11
1888.6	— 4.12	— 4.05	— .07
14.—MICHIGAN CITY, IND.			
1830.5	— 5.58	— 5.57	— .01
1857.7	3.72	4.69	+ .97
1859.7	5.38	4.60	— .78
1871.7	4.03	3.96	— .07
1873.6	— 3.98	— 3.85	— .13
15.—CLEVELAND, OHIO.			
1796.7	— 2.00	— 1.97	— .03
1830.5	1.33	1.06	— .27
1831.6	1.25	1.01	— .24
1834.1	0.83	0.90	+ .07
1838.1	0.58	0.72	+ .14
1840.5	0.32	0.60	+ .28
1841.3	0.09	0.56	+ .47
1845.5	— 0.65	— 0.35	— .30
1859.5	+ 0.77	+ 0.38	+ .39
1871.8	0.54	1.01	— .47
1872.5	0.75	1.04	— .29
1873.5	0.85	1.09	— .24
1876.8	1.13	1.24	+ .11
1880.5	1.64	1.40	+ .24
1888.6	+ 2.06	+ 1.73	+ .33
16.—OMAHA, NEBR.			
1819.7	—12.78	—12.63	— .15
1869.1	10.71	10.96	+ .25
1872.8	10.74	10.72	— .02
1877.8	10.37	10.37	.00
1878.7	10.66	10.30	— .36
1880.8	10.10	10.15	+ .05
1888.7	— 9.49	— 9.56	+ .07

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
17.—BEAVER, PA.			
	°	°	°
1786.5	— 0.72	— 0.72	.00
1866.6	+ 0.62	+ 0.64	— .02
1874.6	1.14	1.17	— .03
1879.5	1.60	1.49	+ .11
1883.7	+ 1.70	+ 1.77	— .07
18.—PITTSBURGH, PA.			
1840.6	+ 0.13	+ 0.21	— .08
1845.3	0.55	0.44	+ .11
1878.7	2.36	2.41	— .05
1884.7	2.68	2.76	— .08
1885.6	+ 2.93	+ 2.82	+ .11
19.—DENVER, COLO.			
1866.5	—15.00	—14.98	— .02
1872.8	14.74	14.79	+ .05
1873.6	14.71	14.76	+ .05
1878.6	14.70	14.58	— .12
1888.8	—14.10	—14.12	+ .02
20.—MARIETTA, OHIO.			
1810.5	— 2.60	— 2.86	+ .26
1824.0	3.42	2.79	— .63
1838.5	1.54	2.39	+ .85
1845.3	2.42	2.10	— .32
1850.5	1.42	1.83	+ .41
1864.1	— 1.21	— 1.01	— .20
1881.4	+ 0.20	+ 0.20	.00
21.—ATHENS, OHIO.			
1796.5	— 4.05	— 4.10	+ .05
1806.5	4.28	4.13	— .15
1838.5	3.20	3.23	+ .03
1880.9	— 0.68	— 0.67	— .01
22.—CINCINNATI, OHIO.			
1806.5	— 4.97	— 4.99	+ .02
1810.5	— 5.00	— 5.02	+ .02

GROUP II.—*Comparison of observed and computed Magnetic Declinations*—Continued.

CINCINNATI, OHIO—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1840.0	— 4.77	— 4.51	— .26
1845.3	4.07	4.30	+ .23
1880.9	2.24	2.34	+ .10
1888.6	— 1.97	— 1.88	— .09

23.—ST. LOUIS, MO.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1835.5	— 8.82	— 8.74	—0.08
1855.5	8.00	7.96	—0.04
1872.6	6.63	6.90	+0.27
1877.5	6.51	6.56	+0.05
1878.6	6.56	6.48	—0.08
1879.7	6.22	6.39	+0.17
1886.8	— 6.18	— 5.88	—0.30

24.—NASHVILLE, TENN.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1829.5	— 6.83	— 6.88	+ .05
1835.5	7.12	6.90	— .22
1877.9	5.25	5.27	+ .02
1888.6	— 4.52	— 4.51	— .01

25.—FLORENCE, ALA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1818.5	— 6.58	— 6.58	.00
1835.5	6.47	6.46	— .01
1865.3	5.40	5.51	+ .11
1875.4	5.24	5.04	— .20
1881.7	— 4.63	— 4.72	+ .09

26.—MOBILE, ALA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1814.5	— 6.50	— 6.50	.00
1835.5	7.20	7.05	— .15
1840.5	7.08	7.07	— .01
1843.5	6.93	7.06	+ .13
1847.4	7.07	7.03	— .04
1857.1	6.87	6.84	— .03
1875.4	6.12	6.09	— .03
1883.2	— 5.28	— 5.66	+ .38

PENSACOLA, FLA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1763.5	— 4.50	— 4.40	—0.10
1775.5	4.50	5.29	+0.79
1807.5	7.83	7.17	—0.66
1817.5	— 8.75	— 7.45	—1.30

PENSACOLA, FLA.—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1835.5	— 6.17	— 7.51	+1.34
1843.5	6.90	7.34	+0.44
1858.5	6.79	6.73	—0.06
1861.0	6.70	6.60	—0.10
1880.0	5.33	5.34	+0.01
1890.2	— 4.92	— 4.57	—0.35

27.—NEW ORLEANS, LA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1700.0	— 2.75	— 2.26	— .49
1720.5	2.00	2.38	+ .38
1750.0	4.60	3.72	— .88
1796.5	5.10	6.92	+1.82
1806.5	8.05	7.46	— .59
1840.5	8.33	8.16	— .17
1857.0	8.00	7.78	— .22
1858.3	7.86	7.73	— .13
1870.5	7.10	7.16	+ .06
1872.1	6.66	7.07	+ .41
1880.2	— 6.46	— 6.58	+ .12

28.—SAN ANTONIO, TEX.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1825.5	—10.50	—10.01	— .49
1836.5	9.75	10.24	+ .49
1874.5	9.50	9.56	+ .06
1878.4	— 9.37	— 9.38	+ .01

29.—KEY WEST, FLA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1750.0	— 5.60	— 5.57	— .03
1829.1	6.42	6.54	+ .12
1843.5	6.03	5.84	— .19
1849.6	5.48	5.49	+ .01
1860.7	4.78	4.81	+ .03
1861.2	4.74	4.77	+ .03
1862.7	4.67	4.68	+ .01
1863.5	4.61	4.62	+ .01
1864.5	4.57	4.56	— .01
1865.5	5.53	4.50	— .03
1866.2	4.50	4.45	— .05
1879.2	3.56	3.62	+ .06
1884.3	2.91	3.30	+ .39
1887.1	— 3.33	— 3.13	— .20

30.—HAVANA, CUBA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1726.5	— 4.57	— 4.36	— .21
1732.3	4.50	4.70	+ .20
1815.5	7.00	6.76	— .24
1816.6	— 5.50	— 6.74	+1.24

HAVANA, CUBA—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1833.0	— 5.83	— 6.17	+ .34
1857.1	5.25	4.93	— .32
1858.5	5.75	4.85	— .90
1879.2	3.90	3.63	— .27
1884.3	2.73	3.33	+ .60
1885.9	3.65	3.24	— .41
1887.0	— 3.58	— 3.18	— .40

31.—KINGSTON, JAMAICA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1726.7	— 4.52	— 5.14	+ .62
1732.2	6.04	5.34	— .70
1791.8	6.78	6.11	— .67
1806.5	6.50	5.85	— .65
1820.0	4.83	5.46	+ .63
1822.5	4.90	5.37	+ .47
1832.5	5.22	5.00	— .22
1833.5	4.67	4.96	+ .29
1837.8	4.30	4.78	+ .48
1847.3	3.67	4.37	+ .70
1857.2	3.67	3.92	+ .25
1875.5	4.00	3.10	— .90
1876.5	3.58	3.05	— .53
1880.5	3.10	2.88	— .22
1884.1	— 2.33	— 2.73	+ .40

32.—BARBADOS, CARIBBEE ISLANDS.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1726.5	— 3.92	— 3.66	— .26
1760.4	4.50	4.22	— .28
1761.4	3.78	4.22	+ .44
1833.5	1.48	1.81	+ .33
1839.5	1.22	1.49	+ .27
1846.5	1.45	— 1.10	— .35
1871.5	— 0.58	+ 0.17	— .75
1884.3	+ 1.58	+ 0.70	+ .88

33.—PANAMA, NEW GRANADA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1775.8	— 7.82	— 7.71	— .11
1790.8	7.82	7.83	+ .01
1802.5	8.00	7.79	— .21
1822.5	7.00	7.49	+ .49
1837.5	7.03	7.09	+ .06
1849.5	7.08	6.69	— .39
1858.5	6.28	6.34	+ .06
1866.4	5.93	6.02	+ .09
1873.9	6.32	5.71	— .61
1880.5	5.40	5.44	+ .04
1883.1	5.03	5.33	+ .30
1884.2	— 5.38	— 5.29	— .09

RESULTS FOR GROUP II—Continued.

Contents of columns: The third column gives the year of the first observation; the fourth, the whole number of observations used in the discussion; the fifth, the probable error of an observation or of an expression; the sixth column gives the year of nearest easterly digression or magnetic elongation, with corresponding amount of maximum *east* declination; the annual change is given for three modern epochs. East declination is indicated by a minus sign, as is also easterly increasing declination; westerly declination and westerly increase are indicated by a plus sign.

Number.	Station.	Year of first observation.	Number of observations.	Probable error of an observation.	Nearest epoch of easterly elongation.	Extreme value of declination at epoch; maximum, when east minimum, when west.	Annual change in 1885.0	Annual change in 1890.0	Annual change in 1895.0
				′		°	′	′	′
1	York Factory, Brit. N. A.	1725	7	±49	1857	− 8.7	+ 9.4	+10.9	+12.2
2	Fort Albany, Brit. N. A.	1668	5	78	1858	+ 8.8	+ 4.7	+ 5.4	+ 6.1
3	Duluth, Minn., & Superior City, Wis.	1859	5	28	1871 (?)	−10.1	+ 1.1(?)	+ 1.5(?)	+ 1.9(?)
4	Sault de Ste. Marie, Mich.	1790	9	9	1828	− 1.2	+ 4.0	+ 4.1	+ 4.1
5	Pierrepont Manor, N. Y.	1823	13	7	1802	+ 2.2	+ 5.0	+ 4.6	+ 4.2
6	Toronto, Canada.	1840	39	2	----	------	+ 2.3	+ 3.8	+ 4.4
7	Grand Haven, Mich.	1825	6	9	1834	− 5.3	+ 7.3	+ 8.0(?)	(?)
8	Milwaukee, Wis.	1859	5	29	1832	− 7.7	+ 5.3	+ 5.4	+ 5.5
9	Buffalo, N. Y.	1797	9	10	1806	+ 0.2	+ 4.8	+ 4.5	+ 4.2
10	Detroit, Mich.	1810	11	10	1800	− 3.2	+ 2.8	+ 2.5	+ 2.1
11	Ypsilanti, Mich.	1815	15	4	1789	− 4.6	+ 3.5	+ 3.1	+ 2.6
12	Erie, Pa.	1786	13	13	1808	− 0.5	+ 3.8	+ 3.5	+ 3.2
13	Chicago, Ill.	1823	4	6	1831	− 6.3	+ 3.7	+ 3.8	+ 3.7
14	Michigan City, Ind.	1830	5	36	1820	− 5.7	+ 3.5	+ 3.5	+ 3.4
15	Cleveland, Ohio.	1796	15	13	1792	− 1.9	+ 2.8	+ 2.6	+ 2.4
16	Omaha, Nebr.	1819	7	9	1823	−12.6	+ 4.5	+ 4.6	+ 4.5
17	Beaver, Pa.	1786	5	5	1814	− 1.3	+ 3.9	+ 3.8	+ 3.7
18	Pittsburgh, Pa.	1840	5	6	1808	− 0.6	+ 3.4	+ 3.2	+ 3.0
19	Denver, Colo.	1866	5	4	1839	−15.4	+ 2.8	+ 3.1	+ 3.4
20	Marietta, Ohio.	1810	7	23	1815	− 2.9	+ 4.2	+ 4.1	+ 3.9
21	Athens, Ohio.	1796	4	5	1803	− 4.1	+ 3.5	+ 3.3	+ 3.0
22	Cincinnati, Ohio.	1806	6	9	1813	− 5.0	+ 3.5	+ 3.4	+ 3.3
23	Saint Louis, Mo.	1835	7	9	1822	− 8.9	+ 4.4	+ 4.4	+ 4.3
24	Nashville, Tenn.	1829	4	5	1834	− 6.9	+ 4.4	+ 4.6	+ 4.7
25	Florence, Ala.	1818	5	7	1821	− 6.6	+ 3.2	+ 3.2	+ 3.2
26	Mobile, Ala.	1814	8	8	1841	− 7.1	+ 3.7	+ 3.9	+ 4.0
--	Pensacola, Fla.	1763	10	34	1828	− 7.6	+ 4.5	+ 4.6	+ 4.6
27	New Orleans, La.	1700	11	22	1836	− 8.2	+ 4.1	+ 4.2	+ 4.3
28	San Antonio, Tex.	1525	4	14	1844	−10.3	+ 3.3	+ 3.6	+ 3.8
29	Key West, Fla.	1750?	14	5	1799	− 7.2	+ 3.6	+ 3.4	+ 3.2
30	Havana, Cuba.	1726	11	29	1797	− 7.0	+ 3.4	+ 3.2	+ 3.0
31	Kingston, Jamaica.	1726	15	25	1778	− 6.2	+ 2.4	+ 2.3	+ 2.1
32	Barbados, Caribbee Islands.	1726	8	21	1760	− 4.2	+ 2.2	+ 1.9	+ 1.7
33	Panama, New Granada.	1775	12	±11	1793	− 7.9	+ 2.5	+ 2.5	+ 2.4

RESULTS FOR GROUP II, CENTRAL SERIES—Completed.

Tabular values of magnetic declinations. Computed magnetic declination at each station for every tenth year of the series, and after 1850 for every fifth year. A plus sign signifies westerly declination, a minus sign easterly declination. The first tabular result for any station indicates that the first observation made there falls between that tabular date and the next one following it.

Year (January 1).	1. York Factory, Brit. N. A.	2. Fort Albany, Brit. N. A.	3. Duluth, Minn., and Superior City, Wis.	4. Sault de Ste. Marie, Mich.	5. Pierrepont Manor, N. Y.	6. Toronto, Canada.	7. Grand Haven, Mich.	8. Milwaukee, Wis.	9. Buffalo, N. Y.	10. Detroit, Mich.	11. Ypsilanti, Mich.	12. Erie, Pa.
	°	°	°	°	°	°	°	°	°	°	°	°
1650	----	----	----	----	----	----	----	----	----	----	----	----
60		+19.5										
70		20.6										
80		21.6										
90		+22.4										
1700	----	+22.6	----	----	----	----	----	----	----	----	----	----
10		22.7										
20	+21	22.5										
30	19.6	22.0										
40	+17.4	+21.2										
1750	+14.8	+20.2	----	----	----	----	----	----	----	----	----	----
60	12.0	19.0										
70	9.0	17.7										
80	5.9	16.2										+0.2
90	+ 2.9	+14.8		+0.0					+0.44			—0.2
1800	+ 0.1	+13.4	----	—0.5	----	----	----	----	+0.22	—3.2	----	—0.46
10	— 2.5	12.1		0.9					0.21	3.11	—4.15	0.52
20	4.7	10.9		1.1	+2.6		—5.0		0.41	2.90	3.65	0.39
30	6.5	10.0		1.16	3.05	+0.8	5.2		0.79	2.55	3.01	—0.09
40	— 7.8	+ 9.3		—1.04	+3.72	+1.32	—5.2		+1.35	—2.09	—2.25	+0.36
1850	— 8.5	+ 8.9	— 9.8	—0.76	+4.52	+1.60	—4.95	—7.4	+2.05	—1.56	—1.44	+0.94
55	8.6	8.9	9.9	0.57	4.96	1.85	4.74	7.2	2.43	1.26	1.03	1.26
60	8.6	8.8	10.02	0.34	5.41	2.17	4.45	6.9	2.84	0.99	0.62	1.60
65	8.5	8.9	10.08	—0.07	5.87	2.39	4.11	6.6	3.25	0.69	—0.21	1.94
70	— 8.2	+ 9.1	—10.11	+0.21	+6.33	+2.66	—3.71	—6.2	+3.67	—0.41	+0.18	+2.30
1875	— 7.7	+ 9.3	—10.10	+0.52	+6.79	+3.14	—3.25	—5.8	+4.09	—0.13	+0.55	+2.65
80	7.2	9.6	10.06	0.84	7.23	3.62	2.73	5.4	4.51	+0.13	0.89	2.99
85	6.4	9.9	9.98	1.18	7.6	3.88	2.15	5.0	4.91	0.37	1.20	3.32
90	5.6	10.3	9.9	1.52	8.0	4.12	1.5	4.5	5.30	0.58	1.48	3.62
95	— 4.6	+10.8	— 9.7	+1.9	+8.4	+4.5	—1	—4.1	+5.66	+0.78	+1.7	+3.9
1900	— 3.6	+11.4	— 9.5	+2.2	+8.8	+4.8	----	—3.6	+6.0	+0.9	+1.9	+4.2

The tabular values for 1900 are but rough predictions.

RESULTS FOR GROUP II, CENTRAL SERIES—Completed.

Year (January 1).	13. Chicago, Ill.	14. Michigan City, Ind.	15. Cleveland, Ohio.	16. Omaha, Nebr.	17. Beaver, Pa.	18. Pittsburgh, Pa.	19. Denver, Colo.	20. Marietta, Ohio.	21. Athens, Ohio.	22. Cincinnati, Ohio.	23. Saint Louis, Mo.
	°	°	°	°	°	°	°	°	°	°	°
1700	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
10											
20											
30											
40											
1750	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
60											
70											
80					—0.42						
90			—1.9		—0.85				—4.0		
1800	-----	-----	—1.9	-----	—1.15	-----	-----	-----	—4.1	—4.89	-----
10			1.7	—12.5	1.30			—2.9	4.1	5.01	
20	—6.2		1.5	12.6	1.28			2.8	3.9	4.99	
30	6.3	—5.6	1.09	12.6	1.11			2.7	3.60	4.82	—8.9
40	—6.2	—5.4	—0.64	—12.4	—0.78	+0.18		—2.33	—3.15	—4.51	—8.6
1850	—6.0	—5.0	—0.14	—12.0	—0.32	+0.68	-----	—1.86	—2.61	—4.08	—8.2
55	5.8	4.8	+0.13	11.8	—0.06	0.96		1.57	2.31	3.83	8.0
60	5.6	4.6	0.40	11.5	+0.23	1.26	—15.14	1.27	2.00	3.57	7.7
65	5.4	4.3	0.67	11.22	0.54	1.56	15.02	0.94	1.68	3.28	7.4
70	—5.14	—4.0	+0.93	—10.90	+0.86	+1.87	—14.88	—0.60	—1.36	—2.99	—7.1
1875	—4.87	—3.8	+1.20	—10.56	+1.19	+2.18	—14.71	—0.26	—1.04	—2.69	—6.7
80	4.58	3.5	1.45	10.21	1.52	2.49	14.52	+0.10	0.73	2.39	6.4
85	4.27	3.2	1.69	9.83	1.85	2.78	14.30	0.45	0.43	2.09	6.0
90	3.96	2.9	1.92	9.46	2.18	3.06	14.06	0.79	—0.14	1.80	5.6
95	—3.6	—2.6	+2.12	— 9.1	+2.49	+3.3	—13.8	+1.1	+0.12	—1.53	—5.3
1900	—3.3	—2.3	+2.3	— 8.7	+2.8	+3.5	-----	+1.4	+0.4	—1.3	—4.9

The tabular values for 1900 are but rough predictions.

RESULTS FOR GROUP II, CENTRAL SERIES—Completed.

Year (January 1.)	24. Nashville, Tenn.	25. Florence, Ala.	26. Mobile, Ala.	.. Pensacola, Fla.	27. New Orleans, La.	28. San Antonio, Tex.	29. Key West, Fla.	30. Havana, Cuba.	31. Kingston, Port Royal, Jamaica.	32. Barbados, Caribbee Islands.	33. Panama, New Granada.
	°	°	°	°	°	°	°	°	°	°	°
1700	-----	-----	-----	-----	—2.3	-----	-----	-----	-----	-----	-----
10					2.2						
20					2.4			—4.0	—4.9	—3.4	
30					2.7			4.6	5.3	3.8	
40					—3.1			—5.2	—5.6	—4.0	
1750	-----	-----	-----	-----	—3.7	-----	-----	—5.7	—5.9	—4.2	-----
60				—4.10	4.4			6.2	6.1	4.2	
70				4.87	5.1			6.5	6.2	4.2	—7.66
80				5.61	5.8			6.8	6.2	—4.0	7.81
90				—6.28	—6.5			—7.0	—6.1	—3.75	—7.88
1800	-----	-----	—5.81	—6.84	—7.12	-----	-----	—7.0	—6.0	—3.4	—7.86
10		—6.50	6.30	7.25	7.62			6.9	5.8	3.0	7.77
20	—6.7	6.58	6.71	7.50	7.96	— 9.8	—6.86	6.6	5.5	2.5	7.60
30	6.9	6.54	6.97	7.56	8.15	10.1	6.50	6.3	5.1	2.0	7.35
40	—6.9	—6.37	—7.07	—7.43	—8.16	—10.3	—6.03	—5.85	—4.7	—1.46	—7.05
1850	—6.7	—6.11	—6.99	—7.12	—8.00	—10.2	—5.47	—5.3	—4.3	— 0.92	—6.69
55	6.5	5.93	6.90	6.90	7.85	10.2	5.17	5.05	4.0	0.65	6.50
60	6.3	5.74	6.75	6.65	7.66	10.1	4.85	4.8	3.8	0.39	6.30
65	6.1	5.53	6.57	6.36	7.44	9.93	4.53	4.5	3.6	—0.14	6.09
70	—5.78	—5.30	—6.36	—6.05	—7.18	— 9.75	—4.21	—4.2	—3.3	+0.10	—5.88
1875	—5.46	—5.06	—6.12	—5.71	—6.90	— 9.54	—3.88	—3.9	—3.1	+0.32	—5.67
80	5.13	4.81	5.84	5.34	6.59	9.30	3.57	3.6	2.9	0.53	5.46
85	4.78	4.55	5.54	4.97	6.26	9.03	3.26	3.3	2.7	0.73	5.25
90	4.40	4.28	5.23	4.59	5.91	8.7	2.96	3.0	2.5	0.9	5.0
95	—4.0	—4.0	—4.9	—4.20	—5.6	— 8.4	—2.7	—2.8	—2.3	+1.0	—4.8
1900	—3.6	—3.8	—4.6	—3.8	—5.2	— 8.1	—2.4	—2.5	—2.1	+1.2	—4.6

The tabular values for 1890 are but rough predictions.

GROUP III.—*Collection of Magnetic Declinations from the earliest to the present time, observed on or near the Pacific coast of the United States and west of the Rocky Mountains, and extending over the region from the Isthmus of Tehuantepec, Mexico, northward to Bering Strait and the Arctic Ocean, coast of Alaska.*

To these are added observations at a station in Kamtchatka and at two stations in the Sandwich Islands. This collection comprises only places for which sufficient data were found for the discussion of the secular change of the declination.

Since the issue of the fifth edition of this paper a valuable collection of magnetic data has been published by Assistant G. Davidson in Appendix No. 7, Report for 1885, entitled "Collection of some Magnetic Variations off the Coasts of California and Mexico, observed by Spanish Navigators in the last Quarter of the Eighteenth Century." The contents of this communication bearing directly upon our researches, it was submitted by me to a careful scrutiny, when its value became at once apparent, as it enabled me to assign for that early period a closely approximate value for the declination for any part of the coast between San Blas, a leading Mexican port at the time, and Vancouver Island. By means of these observations, when properly discussed, almost as satisfactory a value could be given as if it had been directly observed, and consequently I have introduced such results in the general collection of declinations at all places where observations were wanting about that period and in some instances made use of these values as checks on observations which otherwise appeared doubtful. It will therefore be proper to explain the method of procedure and give the results deduced, before presenting the general collection of data for the secular-change stations on the Pacific coast.

All observations in question were made at sea, hence individually they give little reliable information for any particular place, but collectively their value becomes apparent if it can be shown that the probable error of a single observation is reasonably small and that the law of geographical distribution of the declination can be made out satisfactorily. This was effected by plotting all observed values for localities not more than about 4° of arc or about 240 nautical miles distant from the coast and representing the distribution of the declination as a function of the latitude and longitude, but disregarding the effect of the secular change during the interval 1774 to 1790; in other words, making no allowance for reduction to mean epoch.

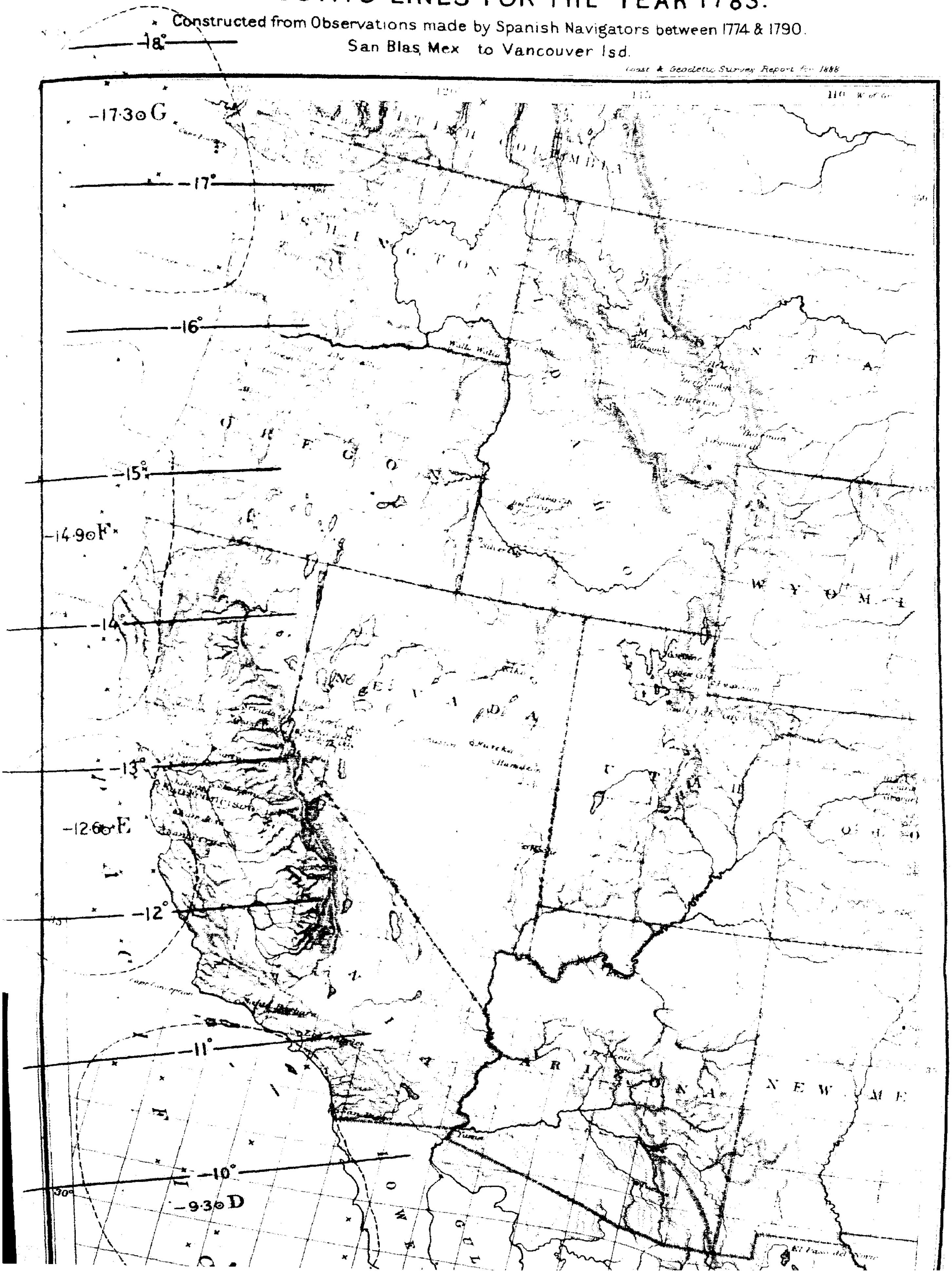
To facilitate treatment of so large a number of observations by application of the method of least squares, the 122 observations selected as within our limit were united into mean values, for 7 groups, which could readily be marked out on the chart. No rejection was made and the values forming each group may be identified, if desired, by the epoch and their latitude and longitude without special reference to Appendix No. 7, Report of 1885. These groups are given below. In the table the groups are marked "A" to "G," and the headings No., τ, φ, λ, D indicate the running number, the year and fraction, the latitude, the west longitude, and the observed declination, respectively.

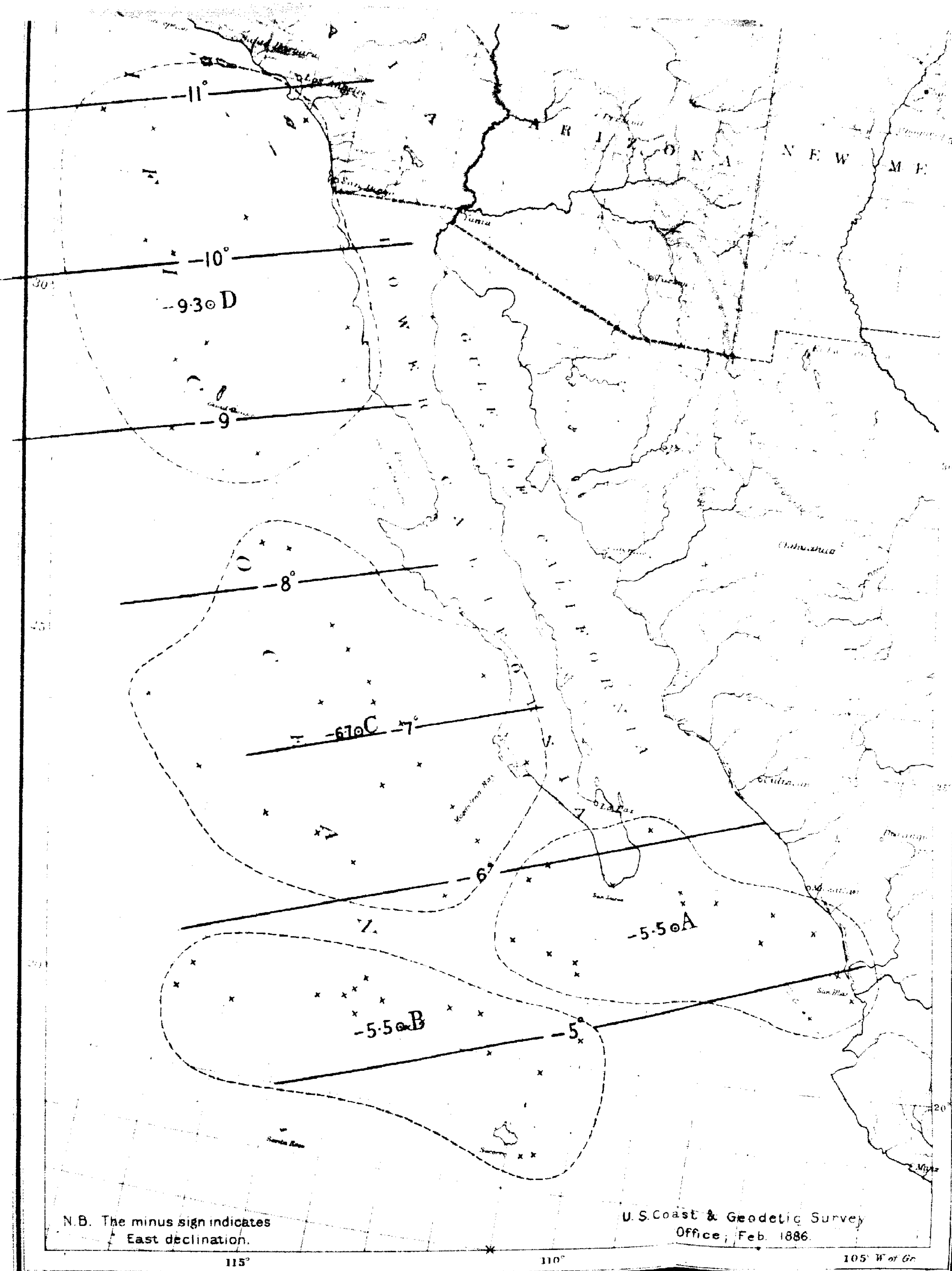
No.	τ	φ	λ	D	No.	τ	φ	λ	D	No.	τ	φ	λ	D
GROUP A.					GROUP A—Continued.					GROUP B.				
		°	°	°			°	°	°			°	°	°
1	1775.2	21.4	110.3	−4.5	10	1779.9	21.6	110.8	−5.0	1	1774.1	20.8	113.8	−5.0
2	90.1	21.2	106.2	−6.0	11	79.9	21.6	110.3	−5.0	2	74.1	20.5	113.4	−5.0
3	90.9	22.7	111.4	−7.5	12	88.2	21.5	104.9	−5.0	3	75.2	20.6	113.9	−4.5
4	90.9	22.8	108.0	−7.0	13	88.9	23.8	109.4	−6.5	4	75.2	20.2	112.9	−4.5
5	90.9	22.7	107.0	−6.0	14	88.8	22.9	108.7	−5.0	5	75.2	19.8	110.7	−5.0
6	90.9	22.5	106.2	−5.0	15	88.8	22.7	108.6	−4.5	6	75.2	18.6	110.5	−5.0
7	79.9	23.0	111.0	−6.5	16	88.8	22.2	107.2	−4.5	7	75.2	18.6	110.7	−5.2
8	79.9	22.8	110.1	−6.0	17	1788.8	21.9	105.8	−4.5	8	79.2	20.6	112.4	−5.0
9	79.9	21.8	111.4	−5.0						9	79.2	20.4	110.0	−5.5

ISOGONIC LINES FOR THE YEAR 1783.

Constructed from Observations made by Spanish Navigators between 1774 & 1790.

San Blas, Mex to Vancouver Isd.





-11°
-10°
-9·3 D
-9°
-8°
-6·7 C
-7°
-6°
-5·5 A
-5·5 B
-5°
ARIZONA
NEW ME
Yuma
La Paz
Chihuahua
San Blas
N.B. The minus sign indicates East declination.
U.S. Coast & Geodetic Survey Office, Feb. 1886.
115°
110°
105° W of Gr.

Group III.—*Collection of Magnetic Declinations from the earliest to the present time*—**Continued.**

No.	τ	φ	λ	D
Group B—Continued.				
		°	°	°
10	1779.2	20.0	111.6	− 6.0
11	79.2	20.1	116.8	− 7.0
12	79.1	20.5	111.8	− 5.0
13	79.2	20.4	114.5	− 6.0
14	88.2	20.2	112.7	− 5.5
15	88.2	20.3	113.8	− 5.5
16	88.2	20.4	116.6	− 6.0
17	90.1	20.5	114.2	− 6.9
18	1790.1	20.2	115.9	− 6.8
Group C.				
1	1779.9	22.3	112.7	− 5.5
2	88.9	24.6	111.6	− 7.0
3	88.8	23.6	112.8	− 5.0
4	79.9	27.1	116.5	− 8.5
5	79.9	26.1	115.6	− 7.5
6	79.9	25.3	114.6	− 7.0
7	79.9	24.4	118.5	− 7.0
8	79.9	23.4	117.3	− 7.0
9	79.9	23.0	116.0	− 6.5
10	79.9	22.8	115.1	− 6.0
11	79.9	22.5	114.3	− 5.5
12	88.9	25.7	112.6	− 9.0
13	88.8	27.1	117.0	− 6.0
14	88.8	25.7	115.2	− 5.0
15	88.8	25.0	114.6	− 5.5
16	88.8	24.7	113.9	− 5.3
17	88.8	24.2	113.5	− 5.2
18	90.8	24.8	115.5	− 8.0
19	90.8	23.8	114.1	− 9.0
20	1790.8	23.1	112.4	− 8.5
Group D.				
1	1779.8	30.9	119.8	−10.5
2	79.8	29.8	118.9	−10.0

No.	τ	φ	λ	D
Group D—Continued.				
		°	°	°
3	1779.9	23.8	117.4	− 9.5
4	88.9	33.4	117.9	−11.0
5	88.9	29.8	116.2	−10.0
6	88.7	32.6	120.8	− 9.0
7	88.7	31.7	118.7	− 8.5
8	88.8	30.6	116.4	− 8.0
9	88.8	28.3	119.0	− 6.9
10	90.8	32.8	121.8	−11.0
11	90.8	31.0	120.4	− 9.0
12	1790.8	29.4	119.3	− 8.5
Group E.				
1	1774.8	36.8	123.0	−11.0
2	74.8	36.2	122.0	−11.0
3	75.7	37.9	123.3	−16.0
4	75.8	37.7	123.8	−15.0
5	75.8	36.7	123.2	−14.0
6	79.8	37.6	123.2	−13.0
7	79.8	37.2	123.1	−12.5
8	79.8	36.0	122.6	−12.0
9	79.8	34.8	122.2	−11.0
10	79.7	37.8	122.8	−13.0
11	88.7	36.2	125.4	−10.5
12	88.7	35.2	124.2	−10.0
13	90.6	37.6	123.4	−14.5
14	90.8	35.3	123.0	−12.0
15	90.7	37.5	123.7	−13.3
16	1790.7	37.1	122.5	−13.0
Group F.				
1	1774.6	42.6	124.3	−15.5
2	74.6	39.8	124.3	−11.2
3	75.4	41.8	125.2	−14.0
4	75.4	41.5	124.8	−14.5
5	75.5	41.0	124.2	−14.0

No.	τ	φ	λ	D
Group F—Continued.				
		°	°	°
6	1775.6	42.4	125.0	−17.0
7	75.7	44.3	125.9	−18.0
8	75.7	42.6	124.6	−17.0
9	75.7	39.7	124.2	−16.0
10	79.7	43.8	128.8	−16.0
11	79.7	42.0	126.8	−15.5
12	79.7	40.9	125.4	−15.0
13	79.7	39.6	124.4	−14.0
14	79.7	39.5	124.6	−13.5
15	79.7	38.9	124.0	−13.0
16	88.7	40.0	125.5	−16.0
17	90.6	43.2	127.9	−15.0
18	90.7	41.3	126.0	−14.5
19	1790.7	39.4	125.4	−13.8
Group G.				
1	1774.6	48.3	125.2	−18.3
2	75.5	47.6	128.4	−17.0
3	75.5	47.5	126.5	−17.0
4	75.5	47.4	126.6	−17.5
5	75.5	46.5	128.4	−16.0
6	75.6	47.1	128.5	−18.0
7	75.6	49.2	128.0	−19.0
8	75.6	49.7	128.0	−18.0
9	75.6	46.2	124.3	−17.0
10	75.7	47.8	129.0	−19.0
11	90.2	49.9	127.6	−17.8
12	90.3	49.0	128.0	−17.1
13	90.3	48.7	128.4	−18.0
14	90.3	49.0	128.8	−18.5
15	90.6	48.2	125.2	−18.0
16	90.6	48.3	125.2	−17.0
17	90.6	48.4	126.4	−15.0
18	90.6	48.9	126.9	−15.5
19	90.6	49.5	127.2	−16.0
20	1790.6	49.6	127.7	−17.0

GROUP III.—*Collection of Magnetic Declinations from the earliest to the present time*—Continued.

RESULTS FOR EACH GROUP.

Group.	τ	φ	λ	D
		°	°	°
A	1875.9	22.3	108.7	− 5.5
B	1780.2	20.2	113.1	− 5.5
C	1785.1	24.5	114.7	− 6.7
D	1787.1	30.3	118.9	− 9.3
E	1782.2	36.7	123.2	−12.6
F	1779.8	41.3	125.3	−14.9
G	1783.0	48.3	127.2	−17.3
Mean	1783.3	31.9	118.7	−10.3

For the relation $D=f(\varphi, \lambda)$ I have found it sufficient to make use of the following terms only, others depending on the square or on higher powers would have no sensible effect upon the result, nor would they be warranted by the uncertainties in the observations themselves:

$$D=D_0+\Delta\varphi.x+\Delta\lambda\cos\varphi.y+\Delta\varphi^2.z$$

where

$\Delta\varphi=\varphi-\varphi_0=\varphi-31^\circ.9$

$\Delta\lambda=\lambda-\lambda_0=\lambda-118^\circ.7$

D_0=normal declination for epoch 1783.3$=-10^\circ.3$

D=declination at that time for any place (within the geographical limits of the investigation) and whose latitude is φ and whose longitude is λ. The conditional equations then become as follows:

$$\begin{aligned}
+4.8&=-\ \ 9.6\,x-9.3\,y+\ 92\,z\\
+4.8&=-11.7\,x-5.3\,y+137\,z\\
+3.6&=-\ \ 7.4\,x-3.6\,y+\ 55\,z\\
+1.0&=-\ \ 1.6\,x+0.2\,y+\ \ 3\,z\\
-2.3&=+\ \ 4.8\,x+3.6\,y+\ 23\,z\\
-4.6&=+\ \ 9.4\,x+5.0\,y+\ 88\,z\\
-7.0&=+16.4\,x+5.6\,y+269\,z
\end{aligned}$$

and the normal equations become:

$$\begin{aligned}
\underline{666.7}\,x+333.7\,y+\ 2456.4\,z+\ 299.6&=0\\
\underline{196.9}\,y+\ \ 250.1\,z+\ 153.3&=0\\
\underline{110957.0}\,z+1036.9&=0
\end{aligned}$$

whence $\begin{cases} x=-0.381\\ y=-0.132\\ z=-0.0006\end{cases}$ and $D=-10^\circ.3-0.381\,\Delta\varphi-0.132\,\Delta\lambda\cos\varphi-0.0006\,\Delta\varphi^2$

which equation leaves the following residuals, observed—computed:

Group.	Obs'd D.	Comp'd D.	O − C
	°	°	°
A	− 5.5	− 5.5	0.0
B	− 5.5	− 5.2	−0.3
C	− 6.7	− 7.0	+0.3
D	− 9.3	− 9.7	+0.3
E	−12.6	−12.6	0.0
F	−14.9	−14.6	−0.3
G	−17.3	−17.4	+0.1

GROUP III.—*Collection of Magnetic Declinations from the earliest to the present time*—Continued.

The remainders in the last column indicate a sufficiently close representation of the observations. For the probable error of the mean of a group we have

$$r=0.674\sqrt{\frac{[vv]}{n-m}}=\pm 0^\circ.205 \text{ or } \pm 12'.$$

On an average the number of observations in a group is 17, hence the probable error r_0 of any individual observation for declination is $0.205\sqrt{17}$ or $\pm 0^\circ.845$ or $\pm 51'$, a tolerably fair value, considering the time when these observations were made. It also compares favorably with the estimated average probable error of an observation made by Vancouver.

To draw the isogonic lines as represented on the accompanying map (No. 24) it was only necessary to find the roots of the above equation for certain assumed values of D, ranging from -5° to -18°, and plot the corresponding values of φ and λ or points for each line.

A comparison of the isogonic lines of 1783 with those of the present time shows that a century ago the general direction of the curves was not very unlike the present one, but they were less crowded than now. In the space between San Blas and the northern part of Vancouver Island we find a change of declination in 1783 of 13°, whereas in the same space we now have 15° of change, and, roughly speaking, the declination a century ago was 4° less easterly than at present in the region of San Blas and 6° less than at present at Vancouver Island.

Series of Magnetic Stations mainly on the Pacific Coast and in the region of and west of the Rocky Mountains.

The stations of this western series are irregularly scattered over the region extending from the Isthmus of Tehuantepec, Mexico, to the Arctic Ocean, Alaska. Added thereto is a station in Kamtchatka, Eastern Siberia, and two on the Sandwich Islands group.

In this series the observations for magnetic declination have been collected and discussed for secular variation at the following places, arranged in order of increasing latitudes:

1. Acapulco, Mexico.
2. Vera Cruz, Mexico.
3. City of Mexico, Mexico.
4. San Blas, Mexico.
5. San Lucas, Lower Cal., Mex.
6. Magdalena Bay, Lower Cal.
7. Cerros Island, Lower Cal., Mex.
8. El Paso, Texas.
9. San Diego, Cal.
10. Santa Barbara, Cal.
11. Monterey, Cal.
12. San Francisco, Cal.
13. Cape Mendocino, Cal.
14. Salt Lake City, Utah.
15. Vancouver, Wash.
16. Wallula, Wash.
17. Cape Disappointment, Wash.

-- Olympia, Wash.

18. Seattle, Duwamish Bay, Wash.
19. Port Townsend, Wash.
20. Nee-ah Bay, Cape Flattery, Wash.
21. Nootka, Vancouver Island.
22. Captain's and Iliuliuk harbors, Unalashka Is'd.
23. Sitka, Alaska.
24. St. Paul, Kadiak Island.
25. Port Mulgrave, Yakutat Bay, Alaska.
26. Port Etches, Alaska.
27. Port Clarence, Alaska.
28. Chamisso Island, Kotzebue Sound.

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29. Petropavlovsk, Kamtchatka.
30. Kailua, Is'd of Hawaii, Sandwich Is'ds.
31. Honolulu, Is'd of Oahu, Sandwich Is'ds.

The first column of the record for any station contains the running number of the declinations used in the discussion, the second the date of observation, the third the observed value, and the fourth the name of the observer, the geographical position of the station, the reference to publication, and other pertinent remarks. Unless otherwise stated, unit weight ($w=1$) is given to each observation in the computation.

GROUP III.—*Collection of Magnetic Declinations, Western Series.*

1.—ACAPULCO, MEXICO.

$\phi=16° 50'.5$ $\lambda=99° 53'.5$ W. of Gr.

(South of Fort San Diego.)

		° ′		
	1630, about.	1½	E.	According to R. Dudley's "Arcano del Mare," Florence, 1646–'47, the declination was 1½° E. off this port. [No use is made of this.—SCH.]
1	1744..	3		Anson; Hansteen's Magnetismus der Erde, 1819.
2	1791, April 29.	7 44		Don A. Malaspina, observed on land. Berliner Jahrbuch, vol. 53, for 1828.
3	1822..	8 40		Hall; in $\phi=16° 50'$, $\lambda=99° 51'$ W. Becquerel's Traité du Magnétisme, Paris, 1846.
4	1828..	9 07		Capt. Beechey; Becquerel, as above.
5	1837..	8 23		Sir Edw. Belcher; Fort San Diego, in $\phi=16° 50'.9$, $\lambda=99° 52'.2$ W. Admiralty chart of Acapulco [Mean —8°.29 for 1838.0—SCH.]
	1838..	8 13		Sir Edw. Belcher; Phil. Trans. Roy. Soc., 1843.
	1838..	8 17		Du Petit Thouars; Voyage of the Frigate Venus.
	1841..	8 17		Duflot de Mofras's Explorations of Oregon, Paris, 1844. [Probably Du Petit Thouars's value; not used.—SCH.]
6	1866, May 30.	8 22		W. Harkness, Prof. U. S.N., in $\phi=16° 50'.1$, $\lambda=99° 52'.3$ W. Observations on Terrestrial Magnetism, Smithsonian Contributions to Knowledge, No. 239, 1873, p. 61.
7	1874, March 17.	8 38.7		G. Dewey, Comdr. U. S. Str. Narragansett, Lieuts. Z. L. Tanner and E. J. Young, observers; in $\phi=16° 50'.5$, $\lambda=99° 55'.4$ W.
8	1880, November 23, 24.	7 56.6		H. E. Nichols, Lieut. U. S. N., assist. U. S. Coast and Geodetic Survey; Cocoanut Grove, close to Prof. Harkness's station of 1866; in $\phi=16° 49'.2$, $\lambda=99° 56'.3$ W.
9	1882, November 18.	7 54	E.	U. S. S. Ranger, Lieut. W. P. Ray, in $\phi=16° 51'$, $\lambda=99° 56'$ W. Naval Professional Papers No. 19, Washington, 1886.

2.—VERA CRUZ, MEXICO.

$\phi=19° 12'.0$ $\lambda=96° 08'.8$ W. of Gr.

(Castle San Juan d'Ulloa.)

		° ′		
	1630, about.	3	W.	According to R. Dudley's "Arcano del Mare," Florencé, 1646–'47, the declination was 3° W. off this coast. [No use is made of this.—SCH.]
1	1726 to 1727.	2 15	E.	Joseph Harris; Phil. Trans. Roy. Soc. (abridged), 1824–'34.
2	1769..	6 40		Encycl. Brit., seventh edition, 1842.
	1769, March 15.	6 28		
3	1776..	7 30		Don Ulloa; Encycl. Brit., seventh edition, 1842.
4	1815..	10 37		Malony; Encycl. Brit., seventh edition, 1842. [Weight ¼ assigned to this value.—SCH.]
5	1819, April 27.	9 16		Wise; Encycl. Brit., seventh edition, 1842.
6	1839..	8 22		Behard; $\phi=19° 12'$, $\lambda=96° 09'$ W. Phil. Trans. Roy. Soc., Sir Edw. Sabine's Contributions to Terr. Magn., No. xiv, vol. 165, 1875.
7	1856, August 7, 8.	8 17		August Sonntag; in $\phi=19° 12'$, $\lambda=96° 09'$ W., at the villa la Guaca, 200 yds. south of the city; Smithsonian Contributions to Knowledge. Washington, 1860; also, Coast Survey Report for 1856, p. 214.
8	1861..	8 20		English Admiralty Chart, No. 523, corrected to 1861.
9	1880, February 10, 11, 12.	7 26.3	E.	Lieut. S. M. Ackley, U. S. N., asst. U. S. Coast and Geodetic Survey; northeast bastion of Castle San Juan d'Ulloa, $\phi=19° 12'.2$, $\lambda=96° 08'.5$ W.

GROUP III.—*Collection of Magnetic Declinations, Western Series*—Continued.

3.—CITY OF MEXICO, MEXICO.

$\phi=19° 26'.0$ $\lambda=99° 11'.6$ W. of Gr.

(Observatorio Nacional.)

		° ′	
1	1769, June.	5 20 E.	Don Alzate; Hansteen's Magnetismus der Erde, 1819.
	1769, December.	5 35	Don Alzate; reference as above.
2	1775..	6 42	Velasquez de Leon; Memoria del Observatorio Meteorologico Central de Mexico; Por V. Reyes, Mexico, 1880.
3	1803, December.	8 08	Alex. von Humboldt; Hansteen's Magnetismus der Erde, 1819.
4	1849..	8 30.2	Gomez de la Cortina; Memoria del Observatorio Meteorologico Central de Mexico; Por V. Reyes, Mexico, 1880.
5	1850..	8 35.2	Velasquez y Teran; F. Diaz Covarrubias's Tratado de Topografia y Geodesia, Mexico, 1869, tomo 1, p. 221.
6	1856, December 10–17.	8 46	August Sonntag; Observations on Terr. Mag. in Mexico, Smithsonian Cont's to Knowl., Washington, 1860; also Coast Survey Report for 1856, p. 214.
7	1858..	8 22.3	Alamazan; in Mem. del Observatorio Central; F. Diaz Covarrubias's Tratado de Top. y. Geod., Mexico, 1869.
8	1860..	8 30	Salazar Llarregui; in Mem. del Observatorio Central; F. Diaz Covarrubias's Tratado, as above.
9	1862..	8 20.5	Diaz Covarrubias; Tratado, as above.
	1862..	8 34.8	Iglesias; Memoria del Observatorio Meteorologico Central de Mexico; Por V. Reyes, Mexico, 1880.
10	1866..	8 08.5	Ponce de Leon; Tratado de Topografia y Geodesia, Mexico, 1869, tomo 1, p. 221.
	1867..	8 09.3	
11	1868..	8 10.0	Fernandez y Diaz Covarrubias; Tratado, as before.
12	1879, September, October, November, December.	8 34.5	Memoria so bre el Departmento Magnetico del Observatorio Meteorologico Central de Mexico, Por V. Reyes, Mexico, 1880. [The weight one-half is given to this value.—SCH.]
13	1884, April 5, 8, 9, 11, 15, 19.	8 19.0 E.	Observatorio Central (at Tacubaya), M. Barcena, director; official, newspaper slip communicated by the Mexican Consul at San Francisco. The observations of April 15 were made by Prof. G. Davidson, assist. Coast and Geodetic Survey; he found 8° 13′.9 E.

4.—SAN BLAS, MEXICO.

$\phi=21° 32'.5$ $\lambda=105° 18'.4$ W. of Gr.

(Custom House.)

		° ′	
	1630, about.	2½ E.	According to R. Dudley's "Arcano del Mare," Florence, 1646–'47, the declination was about 2½° E. [No use is made of this.—SCH.]
1	1714, November 22.	0½	Sauvague le Muet, in the ship Comtesse de Pontchartrain. Communicated by Asst. G. Davidson, Dec. 7, 1887. [Referred to San Blas from Banderas Bay, where le Muet noted "no" variation. $w=\frac{1}{2}$.—SCH.]
2	1788, March 9.	5	Don Esteban Martinez; in the Princessa; $\phi=21° 30'$, $\lambda=105\frac{1}{2}°$ W. Asst. Davidson's collection, Coast and Geodetic Survey Report for 1885, Appendix No. 7. [$w=\frac{1}{2}$—SCH.]
3	1791, April 12.	7 28	Don A. Malaspina; observed on shore. Berliner Astron. Jahrbuch, vol. 53, for 1828; also Encycl. Brit., seventh edition, 1842.
4	1821–'22.	8 40	Hall; Encycl. Brit., seventh edition, 1842.
	1828..	11 06 E.	Capt. F. W. Beechey; Beechey's Narrative of a Voyage to the Pacific, 1825–'28; also Becquerel's Traité du Magnétisme, Paris, 1846. [Not used.—SCH.]

GROUP III.—*Collection of Magnetic Declinations, Western Series*—Continued.

SAN BLAS, MEXICO—Continued.

		° ′	
5	1837..	8 34 E.	Sir Edw. Belcher; in ϕ=21° 32′, λ=105° 16′ W. Phil. Trans. Roy. Soc., 1843.
	1837..	9 09	Du Petit Thouars; Voyage de la Vénus, 1841. Gen. Sir Edw. Sabine's Cont's to Terr. Mag., No. xiv. Phil. Trans. Roy. Soc., vol. 165, part 1, 1875; position in ϕ=21° 32′, λ=105° 16′ W.
6	1838..	8 47	Sir Edw. Belcher; in the Sulphur; reference as above.
7	1839..	9 00	Sir Edw. Belcher; Phil. Trans. Roy. Soc., 1843.
8	1841..	9 12	Duflot de Mofras's Exploration of Oregon, Paris, 1844.
9	1874, February 23, 24, 26.	9 08.2	G. Dewey, Comdr. U. S. S. Narragansett, Lieuts. Z. L. Tanner and E. J. Young, observers, in ϕ=21° 32′.4, λ=105° 18′.7 W.
10	1880, December 5.	9 18.1 E.	H. E. Nichols, Lieut. U. S. N., asst. U. S. Coast and Geodetic Survey; near Custom House, station of Sir E. Belcher of 1839; in ϕ=21° 32′.2, λ=105° 18′.1 W. [w = 1½—SCH.]

5.—SAN LUCAS, LOWER CALIFORNIA, MEXICO.*

ϕ=22° 53′.3 λ=109° 54′.7 W. of Gr.

(Bay of San Lucas.)

		° ′	
1	1709, January 12.	3 E.	Observation by Captain Woods Rogers; in ϕ=22° 16′, λ=114° 09′, to the westward of the Cape. C. Hansteen's "Magnetismus der Erde," Christiania, 1819. [The reduction to the Cape may be assumed as +½°, hence declination —2°.50, with w=½—SCH.]
2	1714, October 21.	1 30	Sauvague le Muet, close under shore, in ϕ=23° 15′, λ=110° 15′. Spanish MS. translated by W. Revely and published by A. Dalrymple in 1790. Communicated by Asst. G. Davidson, Dec. 7, 1887. [w= ½—SCH.]
3	1779, November 15.	6	Sr. Virey and Antonio Bucareli; in ϕ=22° 50′, λ=110° 08′. C. and Geod. Survey Report for 1885, App. No. 7. [w=½—SCH.]
	1783.3	5.85	Value deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; Appendix 12, C. and Geod. Survey Report for 1886. [Not used.—SCH.]
4	1839.5	8 38	Sir Edward Belcher, Phil. Trans. Roy. Soc., 1843 and 1875. In ϕ=22° 52′, λ=109° 53′ W; San Lucas Bay.
5	1841.5	7 53	Duflot de Mofras, Explorations of Oregon, Paris, 1844. In ϕ=22° 52′.5, λ=109° 50′.5 W.
6	1873, June 9.	10 23.3	Lieuts. Z. L. Tanner and E. J. Young; cruise of the U. S. S. Narragansett, G. Dewey, Commander, May, 1873, to March, 1874. In ϕ=22° 53′.3, λ=109° 54′.9. [On Feb. 27, 28, and March 1, 1873, Asst. W. Eimbeck observed at San José del Cabo, in ϕ=23° 03′.6, λ=109° 40′.7, the declination 10° 32′.4 East (Appendix No. 9, Report for 1881). According to observations by G. C. Reiter in 1875 (which see further on), the declination at San Lucas was 12′.6 less east than at San José; but, according to observations by Z. L. Tanner in 1873, it was 44′.1 greater, again according to Lieut. Comdr. Nichols, Feb. 18, 20, 1881, San Lucas had 17′.6 less declination than San José; hence on the average it was 4′.6 more easterly, and Asst. Eimbeck's observation referred to San Lucas gives for 1873.15 the value —10° 37′.0 adopted mean, or —10° 30′ for epoch 1873.3.—SCH.]

* According to R. Dudley's "Arcano del Mare," Florence, 1646–'47, the declination at Cape San Lucas was about 3¼° east at some time between 1600 and 1647. [No use can be made of this at present.—SCH.]

GROUP III.—*Collection of Magnetic Declinations, Western Series*—Continued.

SAN LUCAS, LOWER CALIFORNIA, MEXICO—Continued.

		° ′	
7	1875, January 17.	9 38.8	G. C. Reiter; Cruise of the U. S. S. Narragansett, Nov., 1874, to July, 1875. In $\phi=22° 53'.3$, $\lambda=109° 54'.7$
8	1881, February 20.	9 26.2 E.	Lieut. Comdr. H. E. Nichols, U. S. N., and asst. C. and Geod. Survey. In $\phi=22° 53'.6$, $\lambda=109° 54'.7$ W. Appendix No. 9, Report for 1881.

6.—MAGDALENA BAY, LOWER CALIFORNIA.

$\phi=24° 38'.4$ $\lambda=112° 08'.9$ W. of Gr.

(Near village on Man-of-War Cove.)

		° ′	
	1630, about.	4 E.	According to R. Dudley's "Arcano del Mare," Florence, 1646–'47, the declination was not far from 4° E. [No use is made of this.—SCH.]
1	1714, October 10.	1½	Sauvague le Muet, in the ship Comtesse de Pontchartrain. Communicated by Asst. G. Davidson, Dec. 7, 1887. [$w=½$—SCH.]
2	1783.3	6 47	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
3	1837..	8 15	Du Petit Thouars; voyage of the Frigate Venus.
	1837..	8 17	Voyage of the Frigate Venus. } Gen. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., vol. 165, part I, 1875; Cont's to Terr. Mag., xiv.
4	1839..	9 15	Sir Edw. Belcher in $\phi=24° 38'$, $\lambda=112° 07'$ W.
	1841..	8 15	Duflot de Mofras; Explorations of Oregon, Paris, 1844; in $\phi=24° 36'$, $\lambda=112° 05'$ W. [Not used.—SCH.]
5	1866, June 9.	10 40.5	W. Harkness, Prof. U. S. N.; Cruise of the Monadnock, 1865–'66, Smithsonian Contributions to Knowledge, No. 239, Washington, 1873; in $\phi=24° 40'$, $\lambda=112° 07'$ W.
6	1871, March and June.	11 00	G. Bradford, asst. Coast Survey, near village on Man-of-War Cove, in $\phi=24° 37'.5$, $\lambda=112° 13'.3$ W. Chart in Coast Survey archives.
7	1873, March 5, 6, 7.	10 36.6	W. Eimbeck, assist. Coast Survey, near village on Man of-War Cove, in $\phi=24° 38'.4$, $\lambda=112° 08'.9$ W., near Belcher's and Bradford's stations. Record in Coast Survey archives.
	1873, June 23.	10 30.8	G. Dewey, Comdr. U. S. S. Narragansett; Lieuts. Z. L. Tanner and E. J. Young, observers. [Double weight given to this value.—SCH.]
8	1881, February 24.	10 29.1 E.	H. E. Nichols, Lieut. Comdr. U. S. N., assist. U. S. Coast and Geodetic Survey; at Eimbeck's station of 1873, in $\phi=24° 38'.4$, $\lambda=112° 08'.9$ W. [Double weight given to this value.—SCH.]

7.—CERROS ISLAND, SEBASTIAN VIZCAINO BAY, LOWER CAL., MEX.

$\phi=28° 04'$ $\lambda=115° 12'$ W. of Gr.

(Morro Rodondo Bay.)

		° ′	
1	1714, October 17.	2 E.	Observer: Sauvague le Muet; letter of G. Davidson, Dec. 7, 1887. In $\phi=28° 12'$, $\lambda=117° 45'$. [When referred to Cerros Island $-1°.75$; weight $=⅛$—SCH.]
2	1783.3	8 26 E.	Deduced from 122 observations by Spanish navigators along the coast from San Blas to Nootka. [$w=½$—SCH.]

GROUP III.—*Collection of Magnetic Declinations, Western Series*—Continued.

CERROS ISLAND, SEBASTIAN VIZCAINO BAY, LOWER CAL., MEX.—Continued.

		° ′	
3	1839..	10 46 E.	At San Bartolome Bay, in $\phi=27° 40'$, $\lambda=114° 53'$. Phil. Trans. Roy. Soc., 1843. [Reduction to Cerros Island, S. E. point —8′, hence decl'n —10° 54′—SCH.]
4	1873, February 17, 18.	11 45.2	Asst. W. Eimbeck (G. Davidson in charge of party) at Cerros Island, in $\phi=28° 03'.9$, $\lambda=115° 11'.5$
	1873, September 9.	12 03.5	Lieuts. Z. L. Tanner and E. J. Young. Cruise of the U. S. S. Narragansett, G. Dewey, Comdr. At Cerros Island, in $\phi=28° 02'$, $\lambda=115° 11'$. [Mean or —11° 54′.3 used for epoch 1873.4—SCH.]
5	1874, December 28.	12 09.2	At Cerros Island, in $\phi=28° 02'$, $\lambda=115° 11'$. Lieuts. J. E. Craig and C. Seymour; Cruise of the U. S. S. Narragansett, G. Dewey, Comdr.
6	1881, March 9.	11 58.6	At Cerros Island, in $\phi=28° 03'.4$, $\lambda=115° 11'.3$ H. E. Nichols, Lieut. U. S. N. and Asst. C. and Geod. Survey. C. and Geod. Survey Report for 1881, App. No. 9.
7	1888, March 26, 29, May 31, June 1.	11 40.5	S. E. Bay, Cerros Island, $\phi=28° 03'$, $\lambda=115° 13'$.
		11 38.4 E.	Morro Rodondo Bay, Cerros Island, $\phi=28° 04'$, $\lambda=115° 12'$. Lieut. C. F. Pond; Cruise of the Ranger, F. A. Cook, Comdg. Notice to Mariners Nos. 41 and 52, 1888. [Mean —11° 39′.4 for 1888.32—SCH]

8.—EL PASO, TEX.

$\phi=31° 45'.5$ $\lambda=106° 29'.1$ W. of Gr.

(Fort Bliss.)

		° ′	
1	1852..	12 24 E.	Major W. H. Emory, Commissioner United States and Mexican boundary survey; Amer. Acad. of Sci., vol. vi, new series, 1856. At Frontera in $\phi=31° 49'$, $\lambda=106° 29'$ W.
2	1859, January 20.	12 25.0	J. H. Clark. U. S. Commissioner; Report of Commissioner of General Land Office, 47th Cong., Sen. Exec. Doc. No. 70, Washington, 1882; at Frontera in $\phi=31° 49'$, $\lambda=106° 33'$ W.
3	1878..	12 25.2	At astronomical monument, Fort Bliss; in $\phi=31° 45'.5$, $\lambda=106° 29'.1$ W. Report of Chief of Engineers, U. S. A., for 1879, vol. iii.
4	1884, April 8.	12 05	Prof. G. Davidson, asst. Coast and Geodetic Survey; about 200 yds. north of R. R. depot, in $\phi=31° 45.5'$, $\lambda=106° 27'$ W. MS. at C. and G. Survey Office.
5	1888, December 1, 2.	11 53.8 E.	J. B. Baylor, asst. C. and Geod. Survey. Station on U. S. Reservation, bounded by Missouri, El Paso, Oregon, and Franklin streets. MS. in archives.

Group III.—*Collection of Magnetic Declinations, Western Series*—Continued.

9.—SAN DIEGO, CAL.

$\phi=32^\circ 42'.1$ $\lambda=117^\circ 14.3'$ W. of Gr.

(La Playa, Point Loma.)

		° ′	
1	1714.8	6 E.	Sauvague le Muet. A rough deduction from observations by le Muet in 1714, about the Island of Guadaloupe. Referred differentially to San Diego. Letter of G. Davidson, Dec. 7, 1887. [$w=\frac{1}{2}$ -Sch.]
2	1783.3	10 26	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
3	1792..	11 0	Capt. G. Vancouver; Vancouver's Voyage of Discovery, etc., 1790-'95, vol. 2, p. 475, London, 1798; also Hansteen's Magnetismus der Erde, 1819. In $\phi=32^\circ 39'$, $\lambda=117^\circ 17'$ W. [$w=\frac{1}{2}$—Sch.]
	1793...	11 0	Reference as above; in $\phi=32^\circ 42'$, $\lambda=116^\circ 53'$ W. Observed on board ship on or near the coast. [Not used.—Sch.]
4	1839..	12 20.6	Sir Edw. Belcher; in $\phi=32^\circ 41'$, $\lambda=117^\circ 13'$ W. Phil. Trans. Roy. Soc., 1841.
	1841..	11 0	Duflot de Mofras, Explorations of Oregon, Paris, 1844; in $\phi=32^\circ 39'.5$, $\lambda=117^\circ 17'$ W. [Not used.—Sch.]
5	1851, April 28 to May 7.	12 28.8	G. Davidson, asst. Coast Survey; near La Playa, in $\phi=32^\circ 42'.2$, $\lambda=117^\circ 14'.6$ W., Coast Survey Report for 1856, p. 229.
6	1853, October 15.	12 31.7	Lieut. W. P. Trowbridge, asst. Coast Survey; at La Playa, near the custom house. Coast Survey Report for 1856.
7	1866, June 15.	13 09.4	W. Harkness, Prof. U. S. N; in $\phi=32^\circ 42'$, $\lambda=117^\circ 13'$ W., at La Playa; Smithsonian Contributions to Knowledge, No. 239, Washington, 1873.
	1871, May 28, 29, 30.	14 46.7	G. Davidson, assist. Coast Survey, at New San Diego; in $\phi=32^\circ 43'.1$, $\lambda=117^\circ 09'.7$ W., Coast and Geodetic Survey Report for 1881, App. 9. [Not used, distance from La Playa too great and reduction uncertain.—Sch.]
8	1872, November 19, 20, 21.	13 19.4	G. Davidson, assist. Coast Survey, and S. R. Throckmorton, aid; near La Playa, in $\phi=32^\circ 42'.2$, $\lambda=117^\circ 14'.6$ W.; station of 1851. Coast and Geodetic Survey Report for 1881, App. 9.
	1879..	12 55	Capt. W. A. Jones, from a plan of New San Diego, showing U. S. Barracks. [Not used.—Sch.]
9	1881, April 6.	13 27.6	H. E. Nichols, Lieut. Comdr. U. S. N., asst. Coast and Geodetic Survey, near Davidson's station of 1851, in $\phi=32^\circ 42'.2$, $\lambda=117^\circ 14'.5$ W. Coast and Geodetic Survey Report for 1881, Appendix 9.
10	1888, June 16, 17.	13 04.2 E.	Lieut. C. F. Pond, U. S. N., in U. S. Steamer Ranger at La Playa, in $\phi=32^\circ 42'$, $\lambda=117^\circ 14'$. Notice to Mariners, U. S. Hydr. Office, No. 41, 1888.

10.—SANTA BARBARA, CAL.

$\phi=34^\circ 24'.2$ $\lambda=119^\circ 43'.0$ W. of Gr.

(Astronomical station of 1869.)

		° ′	
1	1714.8	$7\frac{1}{2}$ E.	Sauvague le Muet. A rough deduction from observations by le Muet, 1714, in the vicinity of Guadaloupe Island; referred differentially to Santa Barbara. Letter of G. Davidson, Dec. 7, 1887. [$w=\frac{1}{4}$—Sch.]
2	1783.3	11 22 E.	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.

GROUP III.—*Collection of Magnetic Declinations, Western Series*—Continued.

SANTA BARBARA, CAL.—Continued.

		° ′	
3	1793, November.	10 15 E.	Capt. G. Vancouver; Hansteen's Magnetismus der Erde, 1819. In ϕ=34° 24′, λ=119° 16′ W.
4	1839..	13 28	Sir Edw. Belcher; Phil. Trans. Roy. Soc., 1841. In ϕ=34° 24′, λ=119° 41′ W. [w=½—SCH.]
5	1869, November 16–19.	15 11.9	S. R. Throckmorton (G. Davidson, assist., chief of party), Coast and Geodetic Survey Report for 1881, Appendix 9. In ϕ=34° 24′.2, λ=119° 42′.8 W.; at outermost spur of hill. [w=½—SCH.]
6	1881, April 14.	14 51.9 E.	H. E. Nichols, Lieut. Comdr. U. S. N., assist. Coast and Geodetic Survey; Report for 1881, App. 9. Near long wharf and the Burton House, in ϕ=34° 24′.6, λ=119° 41′.5 W.

11.—MONTEREY, CAL.

ϕ=36° 36′.1 λ=121° 53′.6 W. of Gr.

(Custom House.)

		° ′	
1	1783.3	12 26 E.	Deduced from 122 observations by Spanish navigators along the coast from San Blas to Nootka; see preceding investigation. [w=¼—SCH.]
2	1786, September 14, 15.	11 48	La Perouse (J. F. G. de); at sea, a few miles from the anchorage, variation —11° 57′; and twenty miles north and west from Pt. Pinos —11° 39′. Voyage autour du monde, Paris, 1797, vol. 3, pp. 302 and 390. Communicated by Mr. Marcus Baker, C. and G. Survey.
3	1791, September 23.	10 56	Don A. Malaspina; Berliner Astron. Jahrbuch, vol. 53, for 1828. Observations made on shore.
4	1792, December.	12 22	Capt. G. Vancouver; in ϕ=36° 36′, λ=121° 34′ W.; Vancouver's Voyage of Discovery, etc., 1790–'95, vol. ii, p. 51; London, 1798; also Hansteen's Magnetismus der Erde, 1819.
5	1794, November 13.	12 22	Capt. G. Vancouver; in ϕ=36° 36′, λ=121° 51′ W.; Vancouver's Voyage of Discovery, etc., 1790–'95, vol. iii, p. 337; also Hansteen's Magnetismus der Erde, 1819. Probably taken on shore.
	1818, September.	16 30	Capt. Golovnin (V. M.); apparently at Presidio, in ϕ=36° 36′.2. Voyage around the World, St. Petersburg, 1822, vol. 2. Communicated by Mr. Marcus Baker, Coast Survey. Not used; apparently about 3° in error.—SCH.]
	1827..	15 38	Capt. F. W. Beechey; Phil. Trans. Roy. Soc., vol. 165, 1875, Sir Edw. Sabine's Cont's to Terr. Mag., No. xiv. [Not used.—SCH.]
6	1837..	14 30	Du Petit Thouars; Voyage of the Frigate Venus. Near Monterey.
7	1839..	14 30	Sir Edw. Belcher; in ϕ=36° 36′, λ=121° 53′ W. Phil. Trans. Roy. Soc., 1841.
8	1841..	15 00	Duflot de Mofras; Exploration of Oregon, Paris, 1844, at Presidio, in ϕ=36° 36′, λ=121° 53′ W.
9	1843..	14 00	Chart of the harbor of Monterey, surveyed by Comdr. T. A. Dornin; position of fort, ϕ=36° 36′.4, λ=121° 52′.4 W.
10	1851, February 8.	14 58.3 E.	G. Davidson, asst. Coast Survey; at Point Pinos, astronomical station, in ϕ=36° 37′.8, λ=121° 55′.5 W. Coast Survey Report for 1856, p. 229.

GROUP III.—*Collection of Magnetic Declinations, Western Series*—Continued.

MONTEREY, CAL.—Continued.

		° ′	
11	1854, May 29, 30.	14 58.9 E.	W. P. Trowbridge, Lieut. U. S. A., assist. Coast Survey. Station near barracks of redoubt, in $\phi=36° 36'.2$, $\lambda=121° 53'.8$ W. Coast and Geodetic Survey Report for 1881, Appendix 9.
12	1873, August 30, 31, September 1.	15 55.3	G. Davidson, asst. Coast Survey, and S. R. Throckmorton, aid; near astronomical station; in $\phi=36° 37'.8$, $\lambda=121° 55'.6$ W. Coast and Geodetic Survey Report for 1881, App. 9.
13	1881, April 20.	15 53.9 E.	H. E. Nichols, Lt. Comdr. U. S. N., assist. Coast and Geodetic Survey; near Lieut. Trowbridge's station of 1854; in redoubt, $\phi=36° 36'.2$, $\lambda=121° 53'.8$ W. Coast and Geodetic Survey Report for 1881, App. 9. [$w=2$ —SCH.]

12.—SAN FRANCISCO, CAL.*

$\phi=37° 47'.5$ $\lambda=122° 27'.3$ W. of Gr.

(Presidio.)

		° ′	
1	1783.3	12 55 E.	Deduced from 122 observations by Spanish navigators along the coast from San Blas to Nootka; see preceding investigation.
2	1792, November 20.	12 48	Capt. G. Vancouver; in $\phi=37° 48'$, $\lambda=122° 07'.5$ W. Vancouver's voyage, 1798, vol. 2, p. 27. Taken on board ship, values varying from $-12° 02'$ to $-13° 32'$. Communicated by Mr. Marcus Baker, Coast and Geodetic Survey. [Longitude defective.—SCH.]
	1816, October.	16 05	Kotzebue; Kotzebue's Voyage of Discovery, 1815–'18; in $\phi=37° 48'.6$, $\lambda=122° 12'.5$ W. [Not used.—SCH.]
3	1818, September 20 (O. S.).	15 00	Capt. Golovnin (V. M.); voyage around the world, St. Petersburg, 1822, vol. 2. Communicated by Mr. M. Baker.
	1824	16 00	Kotzebue. [Not used.—SCH.]
4	1827	15 27	Beechey; Becquerel's Traité du Magnétisme, Paris, 1846.
5	1829, December 6.	14 55	Erman (A. G.); Reise um die Erde, Berlin, 1835, vol. 1.
6	1830	14 51	Erman (A. G.); Phil. Trans. Roy. Soc., vol. 165, 1875. Sir Edw. Sabine's Cont's to Terr. Mag., No. xiv.
7	1837	15 20	Sir Edw. Belcher; in $\phi=37° 48'$, $\lambda=122° 23'$ W. Phil. Trans. Roy. Soc., 1841.
	1837	15 00	Du Petit Thouars; voyage of the Frigate Venus.
8	1839	15 20	Sir Edw. Belcher; in $\phi=37° 48'$, $\lambda=122° 23'$ W. Phil. Trans. Roy. Soc., 1841.
9	1841, October.	15 30	Duflot de Mofras; exploration of Oregon, Paris, 1844; in $\phi=37° 48'.5$, $\lambda=122° 28'.4$ W.
	1842, January.	15 30	Duflot de Mofras; as above. *At Fort Point, Golden Gate.*
10	1849–'50.	15 40.8	Ringgold, Comdr. U. S. N.; at Alcatraz Island, harbor of San Francisco.
11	1852, February 18–28.	15 27.6	G. Davidson, asst. Coast Survey; at Presidio, astronomical station; in $\phi=37° 47'.5$, $\lambda=122° 27'.3$ W. Mean of daily maximum and minimum. Coast Survey Report of 1856, p. 229. Mean value $= -15° 28'.8$ See also C. and G. Survey Report for 1881, App. 9.
	1852, March 24.	15 28.8	
	1852, April 21.	15 27.8	
	1852, May 28.	15 31.1 E.	

* According to Sir F. Drake's observations off the Coast of New Albion in 1579 (?), and from data given in R. Dudley's "Arcano del Mare" of 1646–'47 (Carta prima generale d' America, libro secundo), it is probable that about the year 1610, thirty years more or less, the declination was about 8° East. [No use can yet be made of this.—SCH.]

GROUP III.—*Collection of Magnetic Declinations, Western Series*—Continued.

SAN FRANCISCO, CAL.—Continued.

		° ′	
12	1858, June 3–8.	15 49.4 E.	Karl Friesach; Reports Imp. Acad. of Sciences, Vienna, 1860, vol. 38; at Dupont street, near Catholic ch.; in $\phi = 37° 47'.8$, $\lambda = 122° 24'.0$ W.; second set of obsn's corner Stockton and California sts. [Mean value = − 15° 52′.8—SCH.]
	1858, June 10–12.	15 56.2	
13	1866, June 26.	16 25.5	W. Harkness, Prof. U. S. N.; east side of Yerba Buena Island; in $\phi = 37° 49'$, $\lambda = 122° 21'$ W. Smithsonian Contributions to Knowledge, No. 239, Washington, 1873.
14	1871, December 14, 15, 16.	16 23.1	G. Davidson, asst. Coast Survey, and S. R. Throckmorton, aid; at Presidio, station of 1852. Coast and Geodetic Survey Report for 1881, App. 9.
15	1872, October 26, 27, 28.	16 25.7	Reference as above.
16	1873, June 25, 26, 27.	16 25.4	
	1873, August 19–23.	16 24.0	
	1873, November 12–16.	16 25.4	G. Davidson and Wm. Eimbeck, assts. Coast Survey; at Presidio. Reference as above. [Mean for 1873.7 = −16° 24′.8—SCH.]
17	1874, January 10, 12, 13, 14. 1874, February 19, 20, 21.	16 26.9	Reference as above.
18	1879, March 12–15.	16 34.0	G. Davidson and B. A. Colonna, assts. Coast Survey; at Presidio. Reference as above.
19	1880, September 25, 26.	16 28.3	H. E. Nichols, Lieut. U. S. N., asst. Coast and Geodetic Survey; at the Presidio station. Reference as above.
	1880, November 20.	16 39.5	W. H. Dall and M. Baker, Coast and Geodetic Survey; at the Presidio station. Reference as above. [Mean value for 1880–'81 = −16° 33′.9—SCH.]
20	1881, March 30, 31, April 1.	16 33.3	W. Eimbeck, asst. Coast and Geodetic Survey; at Presidio. Reference as above.
	1881, April 26, 27.	16 31.9	H. E. Nichols, Lt. Comdr. U. S. N., asst. Coast and Geodetic Survey; at Presidio station. Reference as above.
	1881, July 12, November 1.	16 32.2	
	1881, June 22, 23, 24, December 1, 2, 3.	16 18.2	J. S. Lawson, asst. Coast and Geodetic Survey; at Presidio station. Reference as above. [Mean of four values = −16° 28′.9 for 1881.48—SCH.]
21	1883, June 3.	16 38.6	R. A. Marr, aid Coast and Geodetic Survey; at Presidio. MS. in archives.
22	1884, September 5–16.	16 32.3	G. Davidson, asst. Coast and Geodetic Survey, and R. A. Marr, aid; at Presidio. MS. in archives.
23	1885, August 4–12.	16 33.4	G. Davidson, asst. Coast and Geodetic Survey, and F. Morse, aid; at Presidio. MS. in archives.
24	1886, April 21–24.	16 33.1	Observers, locality, and reference as before. MS. in archives.
25	1887, November 15–19.	16 33.9	Observers, locality, and reference as before.
26	1888, May 28, 29, 30, 31.	16 33.9	Observers, locality, and reference as before.
27	1889, April 24, 25, 26, 27, 29, May 1.	16 36.3 E.	Observers, locality, and reference as before.

Group III.—*Collection of Magnetic Declinations, Western Series*—Continued.

13.—CAPE MENDOCINO, CAL.

$\phi=40^\circ\ 26'.3$ $\lambda=124^\circ\ 24'.3$ W. of Gr.

(Light-house.)

		° ′	
	1579 (?)	9 E.	Sir Francis Drake; on a map by R. Dudley, in the "Arcano del Mare," and preserved by Petrus Koerius, dated 1646, showing the coast of New Albion, discovered by Sir F. Drake in 1579. Narrative and critical history of America, Justin Winsor, vol. 2. Boston and New York, 1886. [The compass is 1½° south of Cape Mendocino; no use can at present be made of this.—Sch.]
	1693--	2	G. F. G. Carreri, Giro del Mondo, Napoli, 1699; see also Hansteen's Magnetismus der Erde, 1819; in $\phi=40^\circ\ 29'$, $\lambda=124^\circ\ 29'$ W. [Result probably many degrees in error; the narrative states the pilots could give no reason for this strange result; not used.—Sch.]*
1	1783.3	14 10	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
2	1786, September 7, 8.	14 54	La Perouse (J. F. G. de); Voyage autour du monde, Paris, 1797, vol. III, pp. 302, 390. On board the Boussole, in $\phi=40^\circ\ 21'$, $\lambda=124^\circ\ 36'$ W., average declination $=-14^\circ\ 59'$; on board the Astrolabe, about the same position, declination $=-14^\circ\ 48'$. Communicated by Mr. Marcus Baker.
3	1792, April 18.	16 00	Capt. G. Vancouver; near the cape, about ten leagues from it, it bore N. 36° W. Vancouver's Voyage of Discovery, etc., 1790–'95, London, 1798, vol. 1, p. 197. [This would put him in about $\phi=39^\circ\ 58'$, $\lambda=124^\circ\ 12'$ W., probable reduction to the Cape $-0^\circ.25$, hence declination $=-16^\circ.25$—Sch.]
	1792, April 19.	15 00	Same authority, vol. 1, p. 198, on board ship in $\phi=40^\circ\ 03'$, $\lambda=124^\circ\ 09'$ W. Cape Mendocino bore N. 2° W. four leagues from shore. [Probable reduction to Cape $-0^\circ.20$, hence declination $-15^\circ.20$—Sch.]
	1792, April 22.	16 00	Same authority, vol. 1, p. 200. In $\phi=40^\circ\ 32'$, $\lambda=124^\circ\ 32'$ W. [Probable reduction to Cape $+0^\circ.10$, declination $=-15^\circ.90$; mean of three values $=-15^\circ.78$—Sch.]
4	1794, October 3.	14 00	Same authority, vol. III, p. 321. In $\phi=40^\circ\ 42'$, $\lambda=124^\circ\ 30'$ W. [Probable reduction to Cape $+0^\circ.12$, declination $=-13^\circ.88$—Sch.]
5	1854, April 25 to May 2.	17 04.5	G. Davidson, asst. Coast Survey; at Humboldt astronomical station in $\phi=40^\circ\ 44'.7$, $\lambda=124^\circ\ 12'.8$ W. Coast and Geodetic Survey Report for 1881, App. 9. [Probable reduction to Cape $+0^\circ.15$ Hence declination $=-16^\circ\ 56'$—Sch.]
6	1886, April 7, 8, 9, 10.	18 00.5 E.	G. Davidson, asst. Coast and Geodetic Survey, and F. Morse aid; near the light-house in $\phi=40^\circ\ 26'.3$, $\lambda=124^\circ\ 24'.3$ W. MS. in archives.

*** This navigator probably refers to False Cape Mendocino, as we may infer from his latitude. This latter cape is now called Cape Fortunas, and is in $\phi=40^\circ\ 30'.5$, $\lambda=124^\circ\ 22'.8$ W.—Sch.**

GROUP III.—*Collection of Magnetic Declinations, Western Series*—Continued.

14.—SALT LAKE CITY, UTAH.

$\phi=40° 46'.1$ $\lambda=111° 53'.8$ W. of Gr.

(Temple Square, astronomical station.)

		° ′	
1	1850..	15 34 E.	Major W. H. Emory, U. S. A.; Amer. Acad. of Science, vol. vi, new series, 1856. In $\phi=40° 46'$, $\lambda=112° 08'$ W.
2	1866, August.	16 30	Jesse W. Fox; letter from Surveyor-General's Office, dated Aug. 29, 1866. In $\phi=40° 46'$, $\lambda=111° 54'$ W.
3	1869, May 6–15.	16 36.4	G. W. Dean, asst. Coast Survey; Temple Square, near astro'l station; in $\phi=40° 46'.0$, $\lambda=111° 53'.8$ W. Coast and Geodetic Survey Rep. for 1881, App. 9.
4	1872..	17 01	Report of Chief of Engineers, 1879, Part III, p. 2099, at Camp Douglass, near astronomical monument; in $\phi=40° 45'.8$, $\lambda=111° 50'.2$ W.
5	1878, August 15.	16 48.1	Dr. T. E. Thorpe; Proc. Roy. Soc., No. 200, 1880. East of the President's house; in $\phi=40° 46'.1$, $\lambda=111° 53'.7$ W.
	1878, October 26, 28, 29.	16 44.2	J. B. Baylor, aid Coast and Geodetic Survey; near Fourth street south and Second street east of Temple. Coast and Geodetic Survey Report for 1881, App. 9. [Mean of two determinations, —16° 46′.2—SCH.]
6	1881, May 12, 13, 14.	16 28.4	Wm. Eimbeck, asst. Coast and Geodetic Survey; about 25 metres S. E. of astronomical station, Temple Square. Reference as above.
7	1883, November 15, 16, 17.	16 14.1	Wm. Eimbeck, asst. Coast and Geodetic survey, and G. F. Bird, aid; station as above. MS. in archives.
8	1884, October 22, 23, 24.	16 13.6	Observer, locality, and reference as above.
9	1885, November 5–10.	16 29.3	Observer, locality, and reference as above.
10	1887, November 8–11.	16 30.6 E.	W. Eimbeck, asst. Coast and Geod. Survey, and J. H. Turner, aid. Station and reference as above.

15.—VANCOUVER, WASH.

$\phi=45° 37'.5$ $\lambda=122° 39'.7$ W. of Gr.

(Flag-staff of Fort Vancouver.)

		° ′	
1	1788, August 14.	14 26 E.	Gray; Haswell's narrative, communicated by Asst. G. Davidson; in $\phi=45° 27'$, $\lambda=122° 19'$ W. [Probable reduction to Vancouver —8′, hence declination =—14° 34′; the weight one-half is given to this result. The formula established for stations on the coast and epoch 1783.3 would give for this place —16° 00′—SCH.]
2	1839..	19 22	Sir Edw. Belcher; Phil. Trans. Roy. Soc., 1841; in $\phi=45° 37'$, $\lambda=122° 36'$ W.
3	1859..	21 30	S. Garfielde, surveyor-general Washington Territory; MS. communication dated Aug. 24, 1866. [In $\phi=45° 40'$, $\lambda=122° 38'$ W.—SCH.]
4	1860..	20 05	Capt. R. W. Haig, English Commissioner of boundary survey. Phil. Trans. Roy. Soc., vol. 154, part II, 1864. In $\phi=45° 38'$, $\lambda=122° 28'$ W.
5	1881, October 26, 27.	20 53.3 E.	J. S. Lawson, asst. Coast and Geodetic Survey; south of Old Fort in $\phi=45° 37'.5$, $\lambda=122° 39'$ W. Coast and Geodetic Survey Report for 1881, App. 9.

Group III.—*Collection of Magnetic Declinations, Western Series*—Continued.

16.—WALLA WALLA AND WALLULA, WASH.

$\phi=46° 04'$ $\lambda=118° 22'$ W. of Gr.

(Near Court-House; at Walla Walla.)

		° ′	
1	1853..	19 40 E.	Governor I. I. Stevens; North Pacific Railroad Explorations, at Old Fort Walla Walla, in $\phi=46° 04'$, $\lambda=118° 48'$ W. Coast Survey Report for 1856, p. 223. [Approximate reduction to Walla Walla —0°.84—Sch.]
2	1860..	20 30	S. Garfielde, surveyor-general of Washington Territory. In town Walla Walla, or near new Fort Walla Walla, in $\phi=46° 03'$, $\lambda=118° 20'$ W. MS. communication of Aug. 24, 1866.
	1860..	20 00	Capt. J. Mullan, U. S. A.; "Magnetic Variation," by J. B. Stone, New York, 1878. In $\phi=46° 03'$, $\lambda=118° 24'$ W.; in town Walla Walla, near new fort. [Mean, —20.25—Sch.]
3	1861..	20 30	S. Garfielde, surveyor-general Washington Territory; at Wallula, or old Fort Walla Walla. [In $\phi=46° 05'$, $\lambda=118° 55'$ W.; approximate reduction to Walla Walla, —0°.84—Sch.]
4	1881, September 24, 25, 26.	22 04.4	J. S. Lawson, asst. Coast and Geodetic Survey; town of Walla Walla, in $\phi=46° 03'.9$, $\lambda=118° 20'.5$ W. Coast and Geodetic Survey Report for 1881, App. 9.
	1881, September 29, 30, October 1, 2.	19 55.7	J. S. Lawson, asst. Coast and Geodetic Survey, at Wallula, near and north of old fort, in $\phi=46° 07'$, $\lambda=118° 55'$ W. Reference as above. [Approximate reduction to Walla Walla, —0°.84; mean value, —21°.42—Sch.]
5	1887, September 16, 17, 19.	21 10.3 E.	E. Smith, asst. C. and Geod. Survey. At Walla Walla, near astronomical station in Court-House block; in $\phi=46° 03'.8$, $\lambda=118° 20'.8$ MS. in archives.

17.—CAPE DISAPPOINTMENT, WASH.

$\phi=46° 16'.7$ $\lambda=124° 02'.8$ W. of Gr.

(South shore of Baker's Bay.)

		° ′	
1	1783.3	16 23 E.	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
2	1786, September 1, 2.	18 00	La Perouse (J. F. G. de); observed on board the Boussole, Sept. 1, in $\phi=46° 39'$, $\lambda=124° 17'$ W., declination $=-18° 53'$; and Sept. 2, in $\phi=45° 57'$, $\lambda=124° 10'$ W., declination $=-17° 07'$. Voyage autour du Monde, etc., Paris, 1797, vol. iii, pp. 300, 303, 388; communicated by Mr. Marcus Baker.
3	1792, April 27.	18 00	Capt. G. Vancouver; on board ship; in $\phi=46° 14'$, $\lambda=123° 59'$ W., near mouth of Columbia River; Hansteen's Magnetismus der Erde, 1819.
4	1839..	19 11	Sir Edw. Belcher, in Baker's Bay, $\phi=40° 17'$, $\lambda=124° 02'$ W.; Phil. Trans. Roy. Soc., 1841.
5	1842..	20 00	Duflot de Mofras; Exploration of Oregon, Paris, 1844; at mouth of Columbia River.
6	1851, July 5–9.	20 19.1 E.	G. Davidson, asst. Coast Survey; near beach of Baker's Bay, Cape Disappointment, in $\phi=46° 16'.7$, $\lambda=124° 02'.8$ W.; Coast and Geodetic Survey Report for 1881, App. 9.

GROUP III.—*Collection of Magnetic Declinations, Western Series*—Continued.

CAPE DISAPPOINTMENT, WASH.—Continued.

		° ′	
	1851, July 14–19.	20 45.3 E.	Observer and reference as above; on top of Cape at astronomical station, in ϕ=46° 16′.6, λ=124° 03′.0 W. [Not used.—SCH.]
7	1858..	21.00	Communication by S. Garfielde, surveyor-general Washington Territory, dated Aug. 24, 1866.
8	1873, October 24–27.	21 26.5	Wm. Eimbeck, asst. Coast Survey; near beach of Baker's Bay, in ϕ=46° 16′.7, λ=124° 02′.8 W.; Coast and Geodetic Survey Report for 1881, App. 9.
	1873, October 19–23.	21 46.9	Observer and reference as before; on top of Cape at old astronomical station. [Not used.—SCH.]
9	1881, October 14.	21 36.0 E.	H. E. Nichols, Lt. Comdr. U. S. N.; asst. Coast and Geodetic Survey; near beach.

OLYMPIA, WASH.

ϕ=47° 02′ λ=122° 54′ W. of Gr.

		° ′	
1	1783.3	16 35 E.	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
2	1853..	21 15	S. Garfielde, surveyor-general Washington Territory; in ϕ=47° 03′, λ=122° 54′ W.; MS. communication to office of Aug. 24, 1866.
3	1856.5	20 47	Sir Edw. Sabine; Phil. Trans. Roy. Soc., 1872, communication XIII; in ϕ=47° 03′, λ=122° 55′ W. [Compared with observations made at Steilacoom this value seems too small.—SCH.]
4	1881, November 2, 3, 4.	21 34.6 E.	J. W. Lawson, asst. Coast Survey; near Eleventh and Main streets, in ϕ=47° 02′.3, λ=122° 54′.0 W.; Coast and Geodetic Survey Report for 1881, App. 9. [The above observations are insufficient to deduce a satisfactory value for secular change.—SCH.]

18.—SEATTLE, DUWAMISH BAY, WASH.

ϕ=47° 35′.9 λ=122° 20′.0 W. of Gr.

(Astronomical station of 1871.)

		° ′	
1	1783.3	16 45 E.	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
2	1855..	21 25	S. Garfielde, surveyor-general of Washington Terr'y. MS. communication dated Aug. 24, 1866. [In ϕ=47° 36′, λ=122° 20′ W.—SCH.]
3	1871, September 27–October 3.	22 35.4	S. R. Throckmorton, aid Coast Survey; in ϕ=47° 35′.9, λ=122° 20′.0 W. Coast and Geodetic Survey Report for 1881, App. 9. [Result depends on a doubtful azimuth.—SCH.]
4	1881, November 8–11.	22 02.5	J. S. Lawson, asst. Coast and Geodetic Survey; station near that of 1871. Lat. and long. as above. Coast and Geodetic Survey Report for 1881, App. 9.
5	1888, July 9, 10, 11.	22 29.1 E.	E. Smith, asst. C. and Geod. Survey. In the grounds of the University, in ϕ=47° 36′.5, λ=122° 20′.1

Group III.—*Collection of Magnetic Declinations, Western Series*—**Continued.**

19.—PORT TOWNSEND, WASH.

ϕ=48° 07′.0 λ=122° 44′.9 W. of Gr.

(Station Point Hudson.)

		° ′	
1	1783.3	17 00 E.	Deduced from 122 observations of Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
	1792, May.	21 30	Capt. G. Vancouver; at Port Discovery, in ϕ=48° 02′, λ=122° 38′ W. Hansteen's Magnetismus der Erde, 1819. [Apparently about 3° too great, not used.—Sch.]
2	1841--	20 40	Chart by U. S. Exploring Expedition, Commander Wilkes, at Carr Point, in ϕ=48° 03′.3, λ=122° 50′.8 W.
3	1856, August 17–20.	21 39.5	G. Davidson, asst. Coast Survey; at Point Hudson, in ϕ=48° 07′.0, λ=122° 44′.9 W. Coast and Geodetic Survey Report for 1881, App. 9.
4	1857--	21 54	S. Garfielde, surveyor-general Washington Terr'y, at Admiralty Head, Whidbey Island, in ϕ=48° 09′, λ=122° 41′ W. Letter to office dated Aug. 24, 1866. [Reduction to Port Townsend +8′, decl'n = −21° 46′—Sch.]
	1859--	20 45	Reference as above; in ϕ=48° 07′, λ=122° 45′ W. [Not used.—Sch.]
5	1862--	22 00	Reference as above; in ϕ=48° 01′, λ=121° 51′ W., at mill.
6	1876, February.	21 59	Capt. G. H. Burden, U. S. A. Report of Chief of Engineers, U. S. A., 1876, p. 3.
7	1881, November 16, 17, 18.	21 26.9	J. S. Lawson, asst. Coast and Geodetic Survey. Astronomical station of 1852 at Point Hudson, in ϕ=48° 07′.0, λ=122° 45′.0 W. Coast and Geodetic Survey Report for 1881, App. 9.
	1888, July 19, 20.	22 48.8 E.	(?) E. Smith, asst. C. and Geod. Survey; near Marine Hospital, in ϕ=48° 07′.0, λ=122° 45′.1 [Supposed locally affected; not used.—Sch.]

20.—NEE-AH BAY, CAPE FLATTERY, WASH.

ϕ=48° 21′.8 λ=124° 38′.0 W. of Gr.

(Astronomical station, Scarboro' Harbor.)

		° ′	
1	1783.3	17 15 E.	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
	1788, August 15.	19 14	C. Duncan, entrance Strait of Juan de Fuca. On Dalrymple's chart, in ϕ=48° 37′, λ=124° 54′. [Not used.—Sch.]
2	1792, April 30.	18 00	Capt. G. Vancouver; inside Cape Flattery, in ϕ=48° 19′, λ=123° 41′ W. [Supposed misprint for 124° 31′—Sch.] Hansteen's Magnetismus der Erde, 1819.
3	1841--	22 30	Chart of U. S. Exploring Expedition, Commander Wilkes; at Scarborough harbor, north point of Nee-ah Island, in ϕ=48° 21′.8, λ=124° 38′.0 W. [Weight ¼ assigned to this value.—Sch.]
4	1852, August 17–23.	21 29.9	G. Davidson, asst. Coast Survey, and J. Rockwell, aid; at Scarboro' harbor astronomical station, in ϕ=48° 21′.8, λ=124° 38′.0 W. Coast and Geodetic Survey Report for 1881, App. 9.
5	1855, August 13–18.	21 48.2	Lieut. W. P. Trowbridge, asst. Coast Survey; Nee-ah Bay, near Waaddah Island, in ϕ=48° 22′, λ=124° 36′.8 W. Reference as above.
6	1881, October 11.	22 44.2 E.	H. E. Nichols, Lt. Comdr. U. S. N., asst. Coast and Geodetic Survey; near station of 1855. Reference as above.

GROUP III.—*Collection of Magnetic Declinations, Western Series*—Continued.

21.—NOOTKA SOUND, VANCOUVER ISLAND.

$\phi=49° 35'.5$ $\lambda=126° 37'.5$ W. of Gr.

(Friendly Cove.)

		° ′	
1	1778, April 4.	19 45 E.	Capt. J. Cook; in Resolution Cove, $\phi=49° 35'$, $\lambda=126° 37'$ W. Hansteen's Magnetismus der Erde, 1819; also Encyclopædia Metropolitana, 1848. [Cook notes large local attractions on shore at Ship Cove, vol. ii, p. 338, of his Voyage to the Pacific, London, 1784; the value here given was observed on board ship.—SCH.]
2	1783.3	17 54	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
3	1786, August 25, 26.	19 47	La Perouse (J. F. G. de); Voyage autour du monde, etc., Paris, 1797, vol. iii, pp. 300, 310, and 388. Observed about ten miles off shore, on board the Astrolabe, in average $\phi=49° 39'$, and average $\lambda=128° 39'$ W., declination $= -19° 47'$. On board the Boussole in average $\phi=49° 37'$, average $\lambda=127° 22'$ W., declination $= -23° 14'$. Communication by Mr. Marcus Baker, Coast and Geodetic Survey. [The observations on the Boussole not used.—SCH.]
	1791, August 16, 17, September 4.	22 30	Don A. Malaspina; observed on shore; Berliner Astron. Jahrbuch, vol. 53, for 1828. Position on Sept. 4, 1791, in $\phi=49° 57'$, $\lambda=126° 19'$ W. Et. Marchand's Voyage autour du Monde, Paris, an vii, vol. 2. [Not used.—SCH.]
4	1792, October.	18 22	Capt. G. Vancouver; in Nootka Sound, $\phi=49° 34'$, $\lambda=126° 28'$ W. Hansteen's Magnetismus der Erde, 1819.
5	1860..	23 47	G. H. Richards, Capt. R. N., in Friendly Cove, in $\phi=49° 35'.5$, $\lambda=126° 37'.5$ W. Vancouver Island Pilot, Admiralty, London, 1864.
6	1863..	23 05	Observer and locality as above; Admiralty chart of Nootka Sound, No. 1916, 1865. Note: Magnetic variation increasing about 2′ annually.
7	1881, September 27.	23 36.2 E.	H. E. Nichols, Lt. Comdr. U. S. N., asst. Coast and Geodetic Survey; at Friendly Cove. Coast and Geodetic Survey Report for 1881, App. 9. [Double weight has been given to this observation.—SCH.]

22.—UNALASHKA, CAPTAIN'S AND ILIULIUK HARBORS.

$\phi=53° 52'.6$ $\lambda=166° 31'.5$ W. of Gr.

(Greek Church, Iliuliuk Village.)

		° ′	
	1778, October 12.	19 59.2 E.	Capt. J. Cook; Voyage to the Pacific Ocean, London, 1784. Position on shore of Samganuda harbor; in $\phi=53° 55'$, $\lambda=166° 30'$ W. [Not used.—SCH.]
	1789..	19 30	John Henry Cox; Dalrymple's charts. Muscle Cove, in $\phi=53° 50'$. Communicated by Mr. Marcus Baker, Computing Division, Coast Survey, 1879. [Not used.—SCH.]
1	1790, June 4-13.	19 35	Commodore J. Billings; M. Sauer, an account of a geographical and astronomical expedition to the northern parts of Russia, London, 1802. On shore of Beaver Bay, in $\phi=53° 56'$, $\lambda=165° 40'$ W. Communicated by Mr. Marcus Baker. [Weight one-half assigned in discussion.—SCH.]
2	1792..	19 00 E.	Sarycheff; old Russian chart, no date, year doubtful; at Iliuliuk in $\phi=53° 57'$, $\lambda=166° 32'$ W. Communicated by Mr. W. H. Dall, asst. Coast Survey, Nov., 1873.

Group III.—*Collection of Magnetic Declinations, Western Series*—Continued.

UNALASHKA, CAPTAIN'S AND ILIULIUK HARBORS—Continued.

		° ′	
3	1817, June.	19 24 E.	Otto von Kotzebue; Voyage of discovery into the South Sea, London, 1821, Iliuliuk Village, in ϕ=53° 52′.4, λ=166° 31′.9 W. Communicated by Messrs. Dall and Baker, U. S. Coast Survey.
4	1827, August 11.	19 50	Capt. F. P. Lütke; Lenz in Mem. St. Pet. Acad. of Sci., vi., série Math. et Phy. Sc., vol. i, 1838. In ϕ=53° 54′, λ=166° 30′ W. Communicated by Mr. Marcus Baker.
	1829.0	19 54	Capt. F. P. Lütke; Gen. Sabine, in Phil. Trans. Roy. Soc., vol. 162, London, 1872. [Supposed to refer to the same observation as above; not used.—Sch.]
5	1831--	19 30	Vasilieff(?); at sea, north of Akutan. Russian Hydrogr. chart, No. 1379, 1847. In ϕ=54°.4, λ=166°.0 W. Communicated by Mr. Marcus Baker.
	1848--	19 30.5	Russian Hydrographic Office, chart 8. [Supposed to refer to preceding observation; not used.—Sch.]
6	1849--	20 00	Tebenkoff's Atlas, chart No. xxv, near church at Iliuliuk in ϕ=53° 52′, λ=166° 25′ W.
7	1867, September 8, 9.	19 47.4	A. T. Mosman, asst. Coast Survey (G. Davidson, chief of party); on shore at Captain's Harbor at Spithead, in ϕ=53° 53′.9, λ=166° 30′.4 W. Coast and Geodetic Survey Report for 1881, App. 9.
8	1870--	19 45	Kadin; MS. chart of Iliuliuk and Captain's Harbor. Communicated by Mr. W. H. Dall.
	1871, November 11.	18 36	Dr. W. H. Dall, observer; Amaknak Island, opposite village. [Not used.—Sch.]
9	1873, May 26, 27.	19 07.2	Dr. W. H. Dall, observer; near church of Iliuliuk; in ϕ=53° 52′.6, λ=166° 31′.6 W.
	1873, September 17, 18, 19.	18 59.7	Mr. Marcus Baker, observer; Amaknak Island, off village in ϕ=53° 52′.9, λ=166° 31′.7 W. Coast and Geodetic Survey Report for 1881, App. 9. [Weighted mean declination —19° 03′.2 used in discussion.—Sch.]
10	1874, September 15.	18 42.8	Mr. Marcus Baker, observer. Reference as above.
11	1880, July 28, 29.	18 38.0	Messrs. Baker and Dall, Coast and Geodetic Survey, Iliuliuk Harbor; position as in 1873, Amaknak Isd. Reference as before.
12	1883, September 20, 21.	18 42.8 E.	Mr. R. A. Marr, aid, Coast and Geodetic Survey; at spit in Captain's Harbor. MS. in office.

23.—SITKA, ALASKA.

ϕ=57° 02′.9 λ=135° 19′.7 W. of Gr.

(Parade grounds, Sitka.)

		° ′	
	1775, August 23.	22 E.	Don Bruno de Heceta; in ϕ=57° 08′, λ=140° 44′ W.; Coast and Geodetic Survey Report for 1885, App. 7, p. 276; see also F. A. Maurelle, Journal of a voyage to N. W. coast of America, D. Barrington Miscellanies, London, 1781. [At sea; not used.—Sch.]
1	1779, July 7.	23 30 E.	San Virey and Antonio Bucareli; in ϕ=56° 13′, λ=141° 52′ W.; Coast and Geodetic Survey Report for 1885, App. 7, p. 278.

GROUP III.—*Collection of Magnetic Declinations, Western Series*—Continued.

SITKA, ALASKA—Continued.

		° ′	
2	1786, August 6, 7.	26 46 E.	La Perouse (J. F. G. de); Voyage autour du monde, Paris, 1797, vol. iii, pp. 296, 299, 386; mean of four determinations, a few leagues off shore. On board the Boussole, declination =28° 28′ E., in average ϕ=56° 54′ and average λ=135° 26′ W.; on board the Astrolabe, about the same positions, declination =25° 04′ E. [Mean declination =−26° 46′ used.—SCH.] Observations communicated by Mr. Marcus Baker, attached to the Computing Division at the Survey Office in July, 1879.
3	1787, June.	24 00	Capt. G. Dixon; Voyage around the world, London, 1789, at anchor near White's Point, ϕ=57°03′, λ=135° 38′ W. From compass bearings. Communicated by Mr. Marcus Baker.
4	1791, August 8, 11, 21.	27 46	Capt. E. Marchand; Voyage around the world, London, 1801, two volumes. Mean of three values given in vol. ii. One mile north of Dixon's station, in ϕ=57° 04′, λ=135° 39′ W. (In volume i the observer gives the declination =−28° 45′.) Communicated by Mr. Marcus Baker.
5	1804, August 20.	26 45	Capt. U. Lisiansky; Voyage around the world, London, 1814. In ϕ=57° 03′, λ=135° 30′ W.
6	1818, July.	27 15	Capt. V. M. Golovnin; Voyage around the world, St. Petersburg, 1822, vol. ii. Mean of several observations between −24° and −30½°. In ϕ=57° 02′.8, λ=135° 06′.6 W. Communicated by Mr. Marcus Baker.
7	1824, August.	27 30	Capt. Otto von Kotzebue; New voyage around the world, 1823–'26, London, 1830, vol. ii, pp. 66, 77; see also Becquerel's Traité du Magnétisme, Paris, 1846. In ϕ=57° 02′.9, λ=135° 33′.3 W.
8	1827.5	28 50	Capt. F. P. Lütke. Gen'l Sir Edw. Sabine's Conts. to Terr. Mag., No. xiii, Phil. Trans. Roy. Soc., 1872. In ϕ=57° 03′, λ=135° 23′ W.
9	1829, November 10.	28 18.8	Ad. Erman; Reise um die Welt, Berlin, 1835, vols. i and ii; a careful determination on shore, in a place in the rear of the church, in ϕ=57° 02′.7, λ=135° 25′.5 W.
10	1837, September 12–16.	27 42	Sir Edw. Belcher; a careful determination on shore near the Governor's house, in ϕ=57° 03′, λ=135° 26′ W. Sir Edw. Sabine; in Phil. Trans. Roy. Soc., 1841, part i.
	1839, July 15–19.	29 32.5	Sir Edw. Belcher; a careful determination at summer-house in the Governor's garden, in ϕ=57° 03′, λ=135° 22′ W. Sir Edw. Sabine; in Phil. Trans. Roy. Soc., 1843, part i. [Mean of these two values, or − 28° 37′, used for epoch 1838.6—SCH.]
11	1842, every month, except January, February, and October.	28 32.4	At magnetic observatory on Japonski Island, founded in 1842. Hourly observations. In ϕ=57° 02′.9, λ=135° 20′.1 W. Annuaire Mét. et Mag. du Corps des Mines de Russie, St. Pétersbourg, 184– to 184–.*
12	1843, January to December.	28 54.0	
13	1844, January to December.	28 57.3	
14	1845, January to December.	29 00.0	
15	1847, May to December.	28 58.9	At magnetic observatory on Japonski Island. Annales de l'observ. phys. central de Russie, St. Pétersbourg, 184– to 185–.
16	1848, January to December.	29 04.5	
17	1849, January, February, March.	29 03.6	
18	1850, January to December.	28 50.3	
•	1851.0	29 14 E.	Capt. Richard Collinson; MS. in Brit. Hyd. Office. Sir Edw. Sabine in Phil. Trans. Roy. Soc., 1872; Conts. to Terr. Mag., No. xiii. [Not used.—SCH.]

Group III.—*Collection of Magnetic Declinations, Western Series*—Continued.

SITKA, ALASKA—Cotinued.

		° ′	
19	1851, whole year.	28 53.1 E.	See differential observations at magnetic observatory, Japonski Island; Compte Rendu of the Central Physical Observatory of Russia, 1851 to 1864. In 1851–'52–'56 observations during 17 hours each day.
20	1852, January to July, November, and December.	28 48.5	
21	1856..	28 58.6	
22	1857, whole year.	29 07.2	Differential observations as above; in 1857–'58–'59–'60–'61–'63–'64 observations during 19 hours each day.
23	1858, whole year.	29 10.5	
24	1859, whole year.	29 06.1	
25	1860, whole year.	29 07.9	
26	1861..	29 04.1	
27	1862, whole year.	29 00.9	Hourly observations in 1862.
28	1863..	29 03.3	
29	1864..	29 04.2	[Mr. Marcus Baker discussed the magnetic observations at Japonski Island made between 1850 and 1864, incl., and as there was no absolute determination for this period, he based his annual mean values on the computed value resulting from my expression of the secular change of Sitka, given in the preceding edition; thus the differential scale reading 396.0 for 1857.5 corresponds to the declination 29° 07′.2 E., March, 1882.—Sch.]
30	1867, August 17, 18, 19, 20.	28 49	A. T. Mosman, asst. Coast Survey; at old Russian observatory on Japonski Island, harbor of Sitka, in $\phi=57°\ 02'.9$, $\lambda=135°\ 20'.1$ W. Coast Pilot of Alaska by the U. S. Coast Survey, 1869, p. 120.
31	1874, May 4, 5.	28 59.5	M. Baker, U. S. Coast Survey (W. H. Dall, asst. in charge of party); station on parade ground, in $\phi=57°\ 02'.9$, $\lambda=135°\ 19'.7$ W. Coast and Geodetic Survey Report for 1881, App. 9.
32	1876, January 15 to March 20.	28 20.5	Capt. J. B. Campbell and Lt. W. R. Quinan, U. S. A.; Report of Chief of Engineers 1876, part 3, p. 751.
33	1879, April.	28 54	Lieut. J. E. Craig, U. S. S. Alaska; Report to Capt. G. Brown, U. S. N., May 7, 1879, at station of 1874 on parade ground.
34	1880, May 17, 18.	29 04.8	M. Baker and W. H. Dall, U. S. Coast and Geodetic Survey; near old Russian observatory, Japonski Island, in $\phi=57°\ 02'.9$, $\lambda=135°\ 20'.3$ W. Coast and Geodetic Survey Report for 1881, App. 9.
35	1881, September 15, 16.	29 11.2 E.	H. E. Nichols, Lt. Comdr. U. S. N., asst. Coast and Geodetic Survey; on Japonski Island, station of 1880. Reference as above.

* For the collection of the values Nos. 11 to 29 incl., I am indebted to Mr. Marcus Baker, of the Coast Survey, Computing Division, 1879. He discussed the differential hourly observations made at the magnetic observatory between 1842 and 1849, basing the annual means upon the absolute determinations of Jan. 4, 1843, when D=28° 48′.9 E., and of March 4, 1843, when D=28° 57′.3 E. The first value corresponded to scale value 419.3, the second to 432.4 divisions of the differential declinometer.—Sch.

24.—ST. PAUL, KADIAK ISLAND, ALASKA.

$\phi=57°\ 48'.0$ $\lambda=152°\ 21'.3$ W. of Gr.

(Astronomical Station of 1867.)

		° ′	
1	1778, May 21.	23 42 E.	Capt. J. Cook; Voyage to the Pacific Ocean, London, 1784, vol. ii, pp. 507–'8. At sea off Pye Islands in $\phi=59°\ 30'.3$, $\lambda=149°\ 54'$ W.
	1778, June 13.	20 31	Same observer and reference; at sea off S. W. end of Kadiak in $\phi=56°\ 49'$, $\lambda=154°\ 20'$ W. Communicated by Mr. Marcus Baker, C. and G. Survey. [Taking mean values we have for $\phi=58°\ 10'$, $\lambda=152°\ 07'$ W., the value —22° 06′ for epoch 1778.4 The weight one-half is given to this result.—Sch.]

Group III.—*Collection of Magnetic Declinations, Western Series*—**Continued.**

ST. PAUL, KADIAK ISLAND, ALASKA—Continued.

		° ′	
	1779, August 9.	27 0 E.	San Virey and Antonio Bucareli. At sea in $\varphi=57° 59'$, $\lambda=152° 07'$ W. Coast and Geodetic Survey Report for 1885, App. 7, p. 278. [Not used.—Sch.]
2	1790..	25 30	Sarycheff, old Russian chart, no date.
	1790, July 10.	22 10	Fidalgo, in packet Philipino; in $\phi=58° 10'$, $\lambda=152° 07'$ W. Camacho Island in sight. Coast and Geodetic Survey Report for 1885, App. 7, p. 283. [Not used.—Sch.]
3	1804, August 16.	26 07	U. Lisiansky; Voyage, etc., London, 1814, p. 365.
4	1808.. 1808..	26 00 25 30	Russian Naval Officer; old Russian chart, sheet No. xvi. In $\phi=57° 47'.2$, $\lambda=152° 18'.3$ W. Communicated by Mr. M. Baker. [The mean declination $=-25° 45'$ will be used in the discussion.—Sch.]
5	1818, July 19.	26 30	Golovnin (V. M.); Voyage, etc., St. Petersburg, 1822, vol. 2, p. 59. At St. Paul Harbor in front of Governor's house on hill, in $\varphi=57° 47'.2$, $\lambda=152° 18'.3$ W. Communicated by Mr. M. Baker.
6	1834..	28 38	Murasheff; at St. Paul's Harbor. Russian Hydr'c chart No. 1425. Communicated by Mr. M. Baker.
7	1839, July.	26 43	Sir Edw. Belcher, near Cape Greville, in $\phi=57° 20'$, $\lambda=152° 51'$ W. Phil. Trans. Roy. Soc., 1843, part ii.
8	1845 (?)	27 00	Vasilieff; Tebenkoff's Atlas, xxiii. St. Paul's Harbor. Communicated by Mr. M. Baker.
9	1867, August, 28, 29.	26 05	A. T. Mosman, asst. Coast Survey; Harbor of St. Paul at astronomical station on steep rocky bluff about 1½ miles east of village, in $\phi=57° 48'.0$, $\lambda=152° 21'.4$ W. Coast and Geodetic Survey Report for 1881, App. 9.
10	1874, June 7.	25 22	Marcus Baker and W. H. Dall, U. S. Coast Survey; reference as above.
11	1880, July 9.	25 09.2 E.	Observers and reference as above; at Chagafka Cove, harbor of St. Paul.

25.—PORT MULGRAVE, YAKUTAT BAY, ALASKA.

$\phi=59° 33'.7$ $\lambda=139° 45'.9$ W. of Gr.

		° ′	
1	1778, May 6. 1778, May 7.	23 10 E. 24 26	Capt. J. Cook; Voyage to the Pacific Ocean, London, 1784, vol. iii, p. 506. May 6, at sea, off Dry Bank, in $\varphi=59° 08'$, $\lambda=139° 41'$ W. May 7, at sea, near coast south of Mt. St. Elias, in $\phi=59° 27'.5$, $\lambda=140° 53'$ W. Communicated by Mr. Marcus Baker, Coast and Geodetic Survey. [Taking mean values we have for $\phi=59° 18'$, $\lambda=140° 17'$ W. the declination $=-23°.80$ for 1778.3; the weight one-half is given to this value.—Sch.]
2	1787, May.	26 00	Capt. G. Dixon; Voyage around the World, London, 1789.
3	1791, July 1.	26 40	Don A. Malaspina; Bode's Berliner Jahrbuch for 1828; also Espinoza Memorias, 2 vols., Madrid, 1809. On shore in $\phi=59° 33'.7$, $\lambda=139° 46'.3$ W.
4	1794, July.	26 00	Capt. G. Vancouver; A Voyage of Discovery, 1790–'95, London, 1798. At Port Mulgrave, Lieut. Puget, observer, with ship's compass. Communicated by Mr. M. Baker.
5	1802 (about).	29 00 E.	Old Russian chart without date or author; at New Russia Harbor, settled 1795 and destroyed 1803; in $\phi=59° 31'$, $\lambda=139° 36'.5$ W. Communicated by Mr. M. Baker.

GROUP III.—*Collection of Magnetic Declinations, Western Series*—Continued.

PORT MULGRAVE, YAKUTAT BAY, ALASKA—Continued.

		° ′	
6	1823--	30 30 E.	Lieut. Khromchenko, on Russian Hydro'c Chart, No. 1378; at end of spit, in ϕ=59° 33′.6, λ=139° 46′.5 W.
7	1874, May 22.	29 58.3	M. Baker, U. S. Coast Survey, W. H. Dall, chief of party. Coast and Geodetic Survey Report for 1881, App. 9.
8	1880, June 24.	29 59.8 E.	Observer and reference as above. At Yakutat Bay.

26.—PORT ETCHES, PRINCE WILLIAM SOUND, ALASKA.

ϕ=60° 20′.7 λ=146° 37′.6 W. of Gr.

(Astronomical station of 1874.)

		° ′	
1	1778, May 19.	23 37 E.	Capt. J. Cook; Voyage to the Pacific Ocean, 3 vols., London, 1784, vol. iii, p. 507. Communicated by Mr. Marcus Baker, Coast and Geodetic Survey.
2	1787, May.	26 00	Portlock; Voyage, &c., London, 1789; at Chalmer's Harbor, in ϕ=60° 17′, λ=147° 27′ W. Communicated by Mr. M. Baker.
	1787, May and July.	26 30	Observer and reference as above. At Port Etches, Garden Cove, in ϕ=60° 20′.5, λ=146° 46′ W.; maps, pp. 215 and 216. Communicated by Mr. M. Baker.
	1787--	27 00	James Johnstone, Dalrymple's charts, at Cape Hinchinbrock, in ϕ=60° 18′, λ=147° 01′ W. Comm'd by Mr. M. Baker. [Not used.—SCH.]
3	1788, May 17.	25 00	Don Estaban Martinez, in the Princessa. In ϕ=60° 10′, λ=147° 35′ W. Coast and Geodetic Survey Report for 1885, App. 7, p. 281.
4	1790--	26 28	Nuchek, Constantine Redoubt. Sarycheff, old Russian chart without date or number; in ϕ=60° 18′, λ=146° 32′ W. Communicated by Mr. M. Baker.
	1790, May 23.	26 00	Fidalgo, in the packet Philipino. In ϕ=60° 12′, λ=146° 31′ W. Coast and Geodetic Survey Report for 1885, App. 7, p. 283. [Mean value = —26° 14′ used in discussion.—SCH.]
	1790, July 30.	28 30	Commodore J. Billings; M. Sauer, Account of a Geographical and Astronomical Expedition, London, 1802, p. 200. Communicated by Mr. M. Baker. [Not used.—SCH.]
5	1794, June.	28 30	Capt. G. Vancouver; Voyage round the World, London, 1798, vol. iii, p. 188; at Port Chalmers, in ϕ=60° 16′, λ=146° 38′ W. Observed 30 sets with 4 compasses, ranging from —26° 50′ to —30° 09′. Communicated by Mr. M. Baker.
6	1810 (?)	28 07.5	Nuchek; Sarycheff, old Russian chart No. xvii; in ϕ=60° 17′.5, λ=147° 00′ W. Communicated by Mr. M. Baker.
7	1830--	31 38	Nuchek, Constantine Redoubt. Chernoff, Russian Hydr'c Chart No. 1378, published in 1847. In ϕ=60° 20′, λ=146° 32′.5 W.
8	1837, August 27.	31 38	Sir Edw. Belcher, on beach near Phipp's Point, Port Etches. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., 1843, part 2, and Contributions xiii, 1872; in ϕ=60° 21′, λ=146° 41′ W.
9	1874, May 31.	29 09.8 E.	Marcus Baker, U. S. Coast Survey (W. H. Dall, chief of party); at Port Etches, on beach near Phipp's Point. Geographical position as in heading. Coast and Geodetic Survey Report for 1881, App. 9.

GROUP III.—*Collection of Magnetic Declinations, Western Series*—Continued.

27.—PORT CLARENCE, ALASKA.

$\phi=65°\ 16'$ $\lambda=166°\ 50'$ W. of Gr.

(Point Spencer.)

		° ′	
1	1827.5	26 55 E.	Capt. F. W. Beechey; Port Clarence and Grantley Bay, in $\phi=65°\ 17'$, $\lambda=166°\ 19'$ W. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., Contribution xiii; 1872.
2	1850.5	26 26	Captain H. Kellett. Reference as above.
3	1854.5	26 00	Captain Maguire. Reference as above.
4	1879, July.	23 01.3	Aug. Wykander; Nordenskiold in the "Vega." Communicated by Mr. W. H. Dall.
5	1880, September 8.	22 45 E.	Mr. M. Baker, Coast and Geodetic Survey (W. H. Dall, chief of party); at Port Clarence, near Point Spencer, in $\phi=65°\ 16'.1$, $\lambda=166°\ 50'.6$ W. Coast and Geodetic Survey Report for 1881, App. 9.

28.—CHAMISSO ISLAND, KOTZEBUE SOUND, ALASKA.

$\phi=66°\ 13'$ $\lambda=161°\ 49'$ W. of Gr.

		° ′	
1	1826, August.	31 24.3 E.	Capt. F. W. Beechey; Beechey's Narrative of a Voyage to the Pacific, 1825–'28, London, 1831. Communicated by Mr. M. Baker.
	1826.5	31 10	Brit. Admiralty chart, No. 593. Communicated by Mr. M. Baker.
	1826.5	28 53	Capt. F. W. Beechey. Reference as above. Sir Edw. Sabine's Cont's, xiii, Phil. Trans. Roy. Soc., 1872. [Not used.—SCH.]
2	1849.5	30 26	Capt. H. Kellett. Reference as above. In $\phi=66°\ 16'$, $\lambda=161°\ 48'$ W.
3	1880, August 31.	26 49 E.	Mr. M. Baker, Coast and Geodetic Survey (W. H. Dall, in charge of party); at Chamisso Harbor; position $\phi=66°\ 13'.3$, $\lambda=161°\ 48'.7$ W.

29.—PETROPAVLOVSK, KAMCHATKA, SIBERIA.

$\phi=53°\ 01'$ $\lambda=158°\ 43'$ E. of Gr.

		° ′	
1	1779, June.	6 18.7 E.	Capt. J. King; A voyage to the Pacific Ocean, London, 1784. West side of village, in $\phi=53°\ 00'.6$, $\lambda=158°\ 43'.3$ E.
2	1792..	6 00	G. Sarycheff; F. P. Lütke's Voyage around the world, St. Petersburg, 1835.
3	1804, September.	5 20	A. J. von Krusenstern; Voyage around the world, London, 1813. On the spot on which the village stands, in $\phi=53°\ 00'.2$, $\lambda=158°\ 47'.7$ E.
	1804, September.	5 39	Observer and reference as above. On Avatcha Bay. [Mean value = — 5°.49 used in discussion.—SCH.]
	1809, June 23, July 23.	7 21	Capt. Hagemeister; mean value by two compasses. A. G. Erman, Reise um die Erde, Berlin, 1835, vol. ii. Communicated by Mr. M. Baker. [Not used.—SCH.]
	1825.5	4 13 E.	Gen. Sir Edw. Sabine's Cont's to Terr. Mag., No. xiii, in Phil. Trans. Roy. Soc., 1872; in $\phi=53°\ 00'$, $\lambda=158°\ 40'$ E. [This is supposed to refer to Capt. Beechey's observation of 1827; not used.—SCH.]

GROUP III.—*Collection of Magnetic Declinations, Western Series*—Continued.

PETROPAVLOVSK, KAMCHATKA, SIBERIA—Continued.

		° ′	
	1827, July.	4 13.3 E.	Capt. F. W. Beechey; Narrative of a Voyage to the Pacific, 1825–'28, London, 1831; mean of 9 determinations, in $\phi=53°\ 01'$, $\lambda=158°\ 43'.5$ E.
4	1827, September 30.	3 43	Capt. F. P. Lütke; Lenz in Mem. St. Peters. Acad. Sc., vi, vol. i, 1838; in $\phi=53°\ 01'$, $\lambda=158°\ 44'$ E.
	1827, September 30.	4 05.8	A. G. Erman, Reise um die Erde, Berlin, 1835. In $\phi=53°\ 00'.5$, $\lambda=158°\ 40'$ E. [The mean of the three determinations is used giving the middle one the weight one-half, hence for 1827.6 the declination $=-4°.07$—SCH.]
	1829.5	4 04	Gen. Sir Edw. Sabine's Cont's to Terr. Mag., in Phil. Trans. Roy. Soc., 1872. [This is supposed to refer to Erman's value of 1827; not used.—SCH.]
5	1837, September 4.	3 27	Du Petit Thouars; Voyage autour du monde, Paris, 1843. In front of Auchard's house, in $\phi=53°\ 01'$, $\lambda=158°\ 43'$ E.
6	1849.5	2 37	Capt. H. Kellett; Gen. Sir Edw. Sabine in Phil. Trans. Roy. Soc., vol. 162, London, 1872.
7	1854, July.	3 40	Frigate Aurora; Compt-rendu annuel de l'Observatoire Phys. Cent. de Russie, année 1854; St. Pétersbourg, 1855. In $\phi=53°\ 00'$, $\lambda=158°\ 43'.5$ E. [Weight one-half assigned to this value.—SCH.]
	1856, October.	3 24	Admiralty chart, No. 2460; position of Petropavlovsk in Ency. Brit., 7th edition, $\phi=53°\ 01'$, $\lambda=158°\ 43'$ E. [Supposed to be a computed value; not used.—SCH.]
8	1866..	1 25.1	K. S. Staritzky; Onazevich's collection of observations made during hydrographic explorations in the Pacific, 1874–'77; St. Petersburg, 1878.
9	1876, June 11, 13, September 15.	1 09 E.	M. L. Onazevich; reference as above.

N. B.—This important Asiatic station was included in the discussion on account of its proximity to the Western Aleutian or Rat Islands, and as affording the means for connecting the law of secular change with that found to prevail over Siberia. For information No. 3, part of 4, and of Nos. 5, 7, and 9, I am indebted to Mr. Marcus Baker, temporarily (1879) attached to the Computing Division of the Coast and Geodetic Survey Office.

The following two stations on the Hawaiian Islands, which were first introduced in the third edition of the paper on the secular change, are here retained, but *without* giving for them an analytical expression of the law of change. This was thought to be the proper course to pursue in view of the uncertainty now attaching to the former values in consequence of later and important information bearing on the subject.

In a letter addressed to me by Curtis J. Lyons, assistant Government Survey, dated Honolulu, January 9, 1884, Mr. Lyons expresses his conviction that from 1850 to 1884 the secular variation was *increasing* the easterly declination prevailing over the Hawaiian Islands, and cites his experience on Hawaii, viz: "From a number of compass bearings observed by me in 1853 when compared with the respective bearings taken by the same compass and the same observer in 1872–'73, the increase of declination was 40′, hence annual increase 2′.0" Again, in 1873, Mr. Lyons made careful notes of a magnetic bearing of a base line in Oahu and repeated the same with the same instrument in 1884 and found an increase of about 20′, hence annual increase 1′.8 He also states that he knows the spot where Commander Wilkes's observatory stood at Honolulu in 1841, and that the old site is now included in the palace yard; at this place he finds the declination in 1884 to be 9° 30′ E., hence annual increase 1′.7

If it thus be a fact that from about the middle of this century to the present time east declination at the Hawaiian Islands has been on the increase, as believed by Mr. Lyons, the explanation might be found in the presence or obtrusion of a secondary wave of sufficient range to have temporarily overpowered and concealed the ordinary effect of the primary wave of secular motion.

There certainly was indicated by the observations an increase of east declination from the earliest times for which we have any record up to the year 1832, some years more or less, when apparently a maximum was reached; this last feature it would seem we have now to give up and await further development before we can be certain of our deductions.

In a second letter to me dated Honolulu, April 23, 1884, Mr. Lyons gives further information supporting his former statements by fresh observational evidence of direct measures, and gives as his result that the annual increase of easterly declination between 1871 and 1884 was about $\frac{1}{3}$ (1′.9 + 2′.2 + 1′.5) or 1′.9 very nearly.

30.—KAILUA (KAIRUA), HILO AND KEALAKEKUA (KARAKAKOA) BAYS, ISLAND OF HAWAII (OWHYHEE), HAWAIIAN ISLANDS.

$\phi = +19^\circ\ 37'$ $\lambda = 156^\circ\ 01'$ W. of Gr.

(Kailua Bay.)

		° ′	
1	1779..	8 06 E.	Capt. J. Cook; Karakakoa Bay, in $\phi=19^\circ\ 28'$, $\lambda=156^\circ\ 00'$ W. P. Barlow, in Encycl. Metropol., London, 1848; see also Hansteen's Magnetismus der Erde, Christiania, 1819.
2	1791, October 4, 8.	8 02	Capt. Etienne Marchand; west of Hawaii. Voyage autour du Monde, Paris, an vii, vol. 2. On Oct. 4, declination $=8^\circ\ 00'$ E., in $\phi=19^\circ\ 13'$, $\lambda=154^\circ\ 34'$ W.; on Oct. 8, decl'n $=8^\circ\ 05'$ E., in $\phi=19^\circ\ 19'$, $\lambda=157^\circ\ 22'$ W.
3	1795, March.	7 47	Capt. G. Vancouver; A Voyage of Discovery, etc., London, 1804. Mean of 3 compasses on ship and on shore, in $\phi=19^\circ\ 28'.2$, $\lambda=156^\circ\ 02'.2$ W. See also Encycl. Metropol., London, 1848.
4	1796, January 31. 1796..	8 15 9 12	Lieut. W. R. Broughton; Encycl. Metropol., London, 1848. [For first value see Hansteen's Magnetismus der Erde, Christiania, 1819. Second value not used.—SCH.]
5	1818, October.	7 30	Capt. V. M. Golovnin, at Kairua Bay. Voyage around the World, St. Petersburg, 1822, vol. 2.
6	1819..	9 50	Capt. Freycinet; at Kawaihae, in $\phi=20^\circ.5$, northwest Hawaii.
	1824..	10 14	Byron; Island of Owhyhee, in $\phi=19^\circ\ 43'$, $\lambda=156^\circ\ 10'$ W. Gen. Sir Edw. Sabine's Cont's to Terr. Mag., No. xiv; in Phil. Trans. Roy. Soc., vol. 165, pt. i, 1875. [Not used.—SCH.]
7	1825..	8 51	Byron; at Hilo. Communicated by W. D. Alexander, supt. Hawaiian Government Survey, letter of Dec. 11, 1877.
	1836..	7 43	Voyage de la Vénus, Paris, 1841. Position and reference as for the value for 1824, above. [Not used.—SCH.]
8	1841..	8 50	Commander C. Wilkes, U. S. N.; at Hilo. Communicated by Mr. W. D. Alexander, supt. Hawaiian Survey.
9	1845, March 8.	9 27	U. S. Hydrographic Office. U. S. S. Brandywine at sea, in $\phi=19^\circ\ 35'$, $\lambda=158^\circ\ 14'$ W. [Reduction to Kailua +6′, hence declination —9° 21′—SCH.]
10	1853..	8 15	C. J. Lyons, asst. Hawaiian Government Survey; on shore at Kawaihae. Comm'd by Mr. W. D. Alexander, supt. Haw. Survey.
11	1875, August 18.	7 34	H. M. S. Challenger; Hilo, on Cocoanut Island, in $\phi=19^\circ\ 43'.9$, $\lambda=155^\circ\ 04'.0$ W. Rock consists of lava, and very magnetic. Voyage of H. M. S. Challenger, Narrative, vol. ii, London, 1882.
12	1877..	8 10	Observer, C. J. Lyons; in Hamakua and North Hilo, N. E. coast of Hawaii. Comm'd as above for No. 10. [10′ may be subtracted to refer to latitudes of Hilo and Kailua, hence decl'n —8°.0—SCH.]
13	1884.0	8 30 E.	Letter of C. J. Lyons, dated Honolulu, Jan. 9, 1884; considered by him as the best value for this date, as based upon actual survey.

Group III.—*Collection of Magnetic Declinations on Islands in the Pacific Ocean*—Continued.

31.—HONOLULU, ISLAND OF OAHU (WOAHOO), HAWAIIAN ISLANDS.

$\phi=+21^\circ\ 18'.2 \qquad \lambda=157^\circ\ 55'.0$ W. of Gr.

(Fort near town.)

		° ′		
1	1792, March.	7 50	E.	Capt. G. Vancouver; observed on board ship, at anchor in Whyteete Bay, in $\phi=21^\circ\ 16'.8$, $\lambda=157^\circ\ 50'.4$ W. Voyage around the world, London, 1798, vol. i. Communicated by Mr. Marcus Baker, Coast and Geodetic Survey.
	1793..	5 52		Capt. G. Vancouver; at Waikiki, south of Honolulu. Communicated by Mr. W. D. Alexander, supt. Hawaiian Government Survey, in letter dated Mikawao, Maui, Dec. 11, 1877. [Not used.—Sch.]
2	1796, February.	9 41		Lieut. W. R. Broughton; Whyteete Bay, in $\phi=21^\circ\ 18'$, $\lambda=157^\circ\ 59'.5$ W. A Voyage of Discovery, London, 1804. Communicated by Mr. M. Baker.
	1816..	10 57		Kotzebue; at Honolulu. Communicated by Mr. W. D. Alexander, supt. H. S. [Not used.—Sch.]
3	1819..	10 24		Capt. Freycinet; at Honolulu. Reference as above.
4	1824–'25.	9 52		Byron; from L. S. Kaemtz's MSS. Oahu Island, in $\phi=21^\circ\ 17'$, $\lambda=158^\circ\ 00'$ W. Gen. Sir Edw. Sabine's Cont's to Terr. Mag., No. xiv. Phil. Trans. Roy. Soc., vol. 165, pt. i, 1875.
5	1827..	10 26		Capt. Beechey; position and reference as above.
6	1836..	10 11		Voyage de la Bonite, Paris, 1842. Honolulu, in $\phi=21^\circ\ 19'$, $\lambda=157^\circ\ 48'$ W. Ref. to Phil. Trans. as above.
7	1837..	10 00		Voyage de la Vénus, Paris, 1841. Position and reference as above.
	1837..	10 39		Capt. Beechey. } On Oahu Island. Reference as above. [Mean value for
8	1838..	10 39		Capt. Belcher. } 1837.5, =−10°.32—Sch.]
9	1840..	9 17		Berghaus; from L. S. Kaemtz's MSS.; at Honolulu.
	1841..	8 15		Commander C. Wilkes, U. S. N.; at Honolulu. Communicated by Mr. W. D. Alexander, supt. H. S. [Not used.—Sch.]
10	1845, January 25.	10 10		U. S. Hydrographic Office; U. S. S. Brandywine, at sea, in $\phi=21^\circ\ 54'$, $\lambda=157^\circ\ 05'$ W. [Reduction to Honolulu +5′, hence declination = −10° 05′—Sch.]
11	1852..	9 10		Capt. Collinson, MS. in Brit. Hydr. Office. At Honolulu. Gen. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., vol. 165, p. i, 1875.
12	1859, January, February, and March.	9 42		Karl Friesach; Memoirs of the Imperial Academy of Sciences, Vienna, vols. xxix to xliv. In $\phi=21^\circ\ 18'.6$, $\lambda=157^\circ\ 48'.9$ W.
	1867, August.	11 15		Capt. W. Reynolds, U. S. N., in the Lackawanna; Chart No. 6. Wharf near custom-house, in $\phi=21^\circ\ 18'.2$, $\lambda=157^\circ\ 50'.1$ W. [Not used.—Sch.]
13	1871..	9 36		C. J. Lyons, asst. Government Survey; north side of entrance to Honolulu harbor. Comm'd by W. D. Alexander, supt. H. G. S., letter of Dec. 11, 1877.
14	1872..	9 18		Observer and reference as above. On the south side of entrance, at Fisherman's Point.
15	1873..	9 25		Observer as before, in Punchbowl street, in $\phi=21^\circ\ 18'$, $\lambda=157^\circ\ 52'$ W Comm'd by C. J. Lyons, letters of Jan. 9 and Apr. 23, 1884.
	1873..	9 50		Observer and reference as before. West base Oahu triangulation, Honolulu. [Mean value for 1873.5, =−9°.63—Sch.]
16	1875..	9 16		W. D. Alexander; entrance of Pearl Locks, Oahu, and throughout Ewa district. Reference as for 1871.
	1875, July 29, 30, August 10.	9 40.4		H. M. S. Challenger; on spit south of town in $\phi=21^\circ\ 18'.0$, $\lambda=157^\circ\ 51'$ W. Voyage of H. M. S. Challenger, Narrative, vol. ii, London, 1882.
	1875..	9 15	E.	Observer and reference as for first value of 1875. Shore of Waikiki, south of Honolulu. [Mean value =−9°.40—Sch.]

GROUP III.—*Collection of Magnetic Declinations on Islands in the Pacific Ocean*—Continued.

HONOLULU, ISLAND OF OAHU (WOAHOO), HAWAIIAN ISLANDS—Continued.

		° ′		
17	1879..	9 32	E.	Observer, position, and reference as for 1873.
18	1881..	9 40		Observer, position, and reference as for 1873.
19	1883, June 17.	10 42		Lieut. W. H. Parker in the U. S. S. Essex; at sea, in $\phi=21° 15'$, $\lambda=156° 13'$ W. Naval Professional Papers, No. 19, Washington, 1886. [Reduction to Honolulu inappreciable.—SCH.]
	1883, August 19.	9 09		Lieut. F. Hanford in the U. S. S. Pensacola; at sea, in $\phi=21° 10'$, $\lambda=157° 54'$ W. Naval Professional Papers, No. 19, Washington, 1886. [Reduction to Honolulu —3′, hence decl'n = —9° 12′; mean value for 1883.54, = —9°.95—SCH.]
20	1884.0.	10 14		Observer and reference as for 1873, at west base, Honolulu.
	1884.0.	9 30		C. J. Lyons, asst. H. G. S.; at old station of 1841, occupied by Commander C. Wilkes. Letters of Jan. 9 and Apr. 23, 1884.
	1884, January 4.	9 57	E.	Lieut. W. Swift in U. S. S. Alert; at sea, in $\phi=20° 35'$, $\lambda=157° 45'$ W. Naval Professional Papers, No. 19, Washington, 1886. [Reduction to Honolulu —10′, hence declination = —10° 07′. Mean of 3 determinations = —9° 57′—SCH.]

The values available for discussion of the declination at the Hawaiian Islands after rejecting 3 apparently anomalous ones for Kailua and 4 such in the Honolulu series, are as follows:

KAILUA BAY, HAWAII.

No.	Year.	Decl'n.	No.	Year.	Decl'n.	No.	Year.	Decl'n.	No.	Year.	Decl'n.
		°			°			°			°
1	1779.5	—8.10		(1796.0)	(—9.20)	7	1825.5	—8.85	10	1853.5	—8.25
2	1791.7	8.03	5	1818.8	7.50		(1836.5)	(7.62)	11	1875.6	7.57
3	1793.2	7.78	6	1819.5	9.83	8	1841.5	8.83	12	1877.5	8.00
4	1796.0	8.25		(1824.5)	(10.23)	9	1845.2	9.35	13	1884.0	8.50

HONOLULU, OAHU.

No.	Year.	Decl'n.	No.	Year.	Decl'n.	No.	Year.	Decl'n.	No.	Year.	Decl'n.
		°			°			°			°
1	1792.2	—7.83	5	1827.5	—10.43	10	1845.1	—10.08	15	1873.5	—9.63
	(1793.5)	(5.87)	6	1836.5	10.18	11	1852.5	9.17	16	1875.5	9.40
2	1796.1	9.68	7	1837.5	10.32	12	1859.2	9.70	17	1879.5	9.54
	(1816.5)	(10.95)	8	1838.5	10.65		(1867.6)	(11.25)	18	1881.5	9.67
3	1819.5	10.40	9	1840.5	9.28	13	1871.5	9.60	19	1883.5	9.95
4	1825.0	9.87		(1841.5)	(8.25)	14	1872.5	9.30	20	1884.0	9.95

Observations inclosed within parentheses are proposed for omission in any process for representation that may be employed.

No expression of the above observations by means of a periodic function will for the present be attempted, as it seems impossible, without undue and arbitrary straining, to reconcile such a formula with the condition imposed by Mr. Lyons, *i. e.*, that the easterly declination was *increasing* on the islands from about the middle of the century to the present time; we therefore prefer to suspend our judgment as to the direction and amount of the secular change at the present time, and shall wait for further development.

In a volcanic region like that of the Hawaiian Islands it is absolutely essential for the elucidation of the secular change in any of the magnetic elements that the successive observations should be made at the *same* stations, otherwise local disturbances may completely hide the true progressive movement and render all comparison nugatory. Even with this precaution we are obliged to assume that the law of secular change has not at times been suddenly interrupted through the agency of volcanic eruptions or through the effects of earthquakes.

A complete magnetic survey of this group of islands could not fail to throw much light on the distribution and character of the local disturbances, as well as furnish evidence whether or not the secular change over disturbed and undisturbed regions is the same, and it is to be hoped that it will be undertaken by the Hawaiian Government Survey.

The Hawaiian Islands group is magnetically considered no less interesting than are the Bermuda Islands, in which latter group, however, there is less liability to abrupt local changes in the curves representing the distribution of magnetism than in the former.

RESULTS FOR GROUP III.—Magnetic stations on the Pacific coast and Rocky Mountain region; also in Mexico and Alaska and in some foreign countries.

In the last column of the table the letter D stands for declination, the minus sign indicating east declination. The letter m stands for $t-1850.0$ or for the difference in time, expressed in years and fraction of a year, for any time t and the middle of the century; it is to be taken within the range of observation at any station.

No.	Name of station and State.	Latitude.	West longitude.	The magnetic declination expressed as a function of time.
		° ′	° ′	° ° °
1	Acapulco, Mexico.	16 50.5	99 52.3	D=− 4.48+ 4.41 sin (1.0 m− 85.7)*
2	Vera Cruz, Mexico.	19 11.9	96 08.8	D=− 5.09+ 4.22 sin (1.2 m− 63.4)*
3	City of Mexico, Mexico.	19 26.0	99 11.6	D=− 5.34+ 3.28 sin (1.0 m− 87.9)*
4	San Blas, Mexico.	21 32.5	105 18.4	D=− 5.21+ 4.26 sin (1.15 m− 96.5)
5	San Lucas, Lower Cal., Mex.	22 53.3	109 54.7	D=− 5.94+ 3.68 sin (1.20 m−116.8)*
6	Magdalena Bay, Lower California.	24 38.4	112 08.9	D=− 6.33+ 4.17 sin (1.15 m−119.2)*
7	Cerros Island, Lower Cal., Mex.	28 04	115 12	D=− 7.40+ 4.61 sin (1.05 m−107.0)
8	El Paso, Tex.	31 45.5	106 27.0	D=− 9.08+ 3.40 sin (1.3 m−108.4)
9	San Diego, Cal.	32 42.1	117 14.3	D=−10.32+ 3.00 sin (1.10 m−126.5)
10	Santa Barbara, Cal.	34 24.2	119 43.0	D=−11.52+ 3.32 sin (1.10 m−123.1)
11	Monterey, Cal.	36 36.1	121 53.6	D=−13.25+ 2.83 sin (1.10 m−144.0)
12	San Francisco, Cal.	37 47.5	122 27.3	D=−13.94+ 2.65 sin (1.05 m−135.5)
13	Cape Mendocino, Cal.	40 26.3	124 24.3	D=−15.25+ 2.45 sin (1.10 m−128.0)*
14	Salt Lake City, Utah.	40 46.1	111 53.8	D=−12.40+ 4.25 sin (1.4 m−121.6)*
15	Vancouver, Wash.	45 37.5	122 39.7	D=−17.93+ 3.12 sin (1.35 m−134.1)*
16	Walla Walla, Wash.	46 04	118 22	D=−17.80+ 3.30 sin (1.3 m−129.0)*
17	Cape Disappointment, Wash.	46 16.7	124 02.8	D=−19.39+ 2.54 sin (1.25 m−158.7)
18	Seattle, Wash.	47 35.9	122 20.0	D=−19.19+ 3.14 sin (1.4 m−136.1)*
19	Port Townsend, Wash.	48 07.0	122 44.9	D=−18.84+ 3.00 sin (1.45 m−122.1)
20	Nee-ah Bay, Wash.	48 21.8	124 38.0	D=−19.83+ 2.91 sin (1.40 m−141.6)
21	Nootka, Vancouver Island.	49 35.5	126 37.5	D=−21.25+ 2.74 sin (1.30 m−152.0)*
22	Captain's and Iliuliuk Harbors.	53 52.6	166 31.5	D=−18.01+ 1.82 sin (1.3 m− 69.6)*
23	Sitka, Alaska.	57 02.9	135 19.7	D=−25.79+ 3.30 sin (1.30 m−104.2)
24	St. Paul, Kadiak Island.	57 48.0	152 21.3	D=−22.21+ 5.18 sin (1.35 m− 72.5)
25	Port Mulgrave, Alaska.	59 33.7	139 45.9	D=−24.03+ 7.77 sin (1.30 m− 85.8)
26	Port Etches, Alaska.	60 20.7	146 37.6	D=−23.71+ 7.89 sin (1.35 m− 80.9)
27	Port Clarence, Alaska.	65 16	166 50	D=−18.98+ 7.99 sin (1.3 m− 68.4)*
28	Chamisso Island, Alaska.	66 13	161 49	D=−23.62+ 7.64 sin (1.3 m− 64.0)*
29	Petropavlovsk, Siberia.	53 01	201 17	D=− 3.35+ 2.97 sin (1.3 m+ 12.2)

* Approximate expression.

Group III.—*Comparison of observed and computed Magnetic Declinations.*

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1.—ACAPULCO, MEX.			
	°	°	°
1744.5	—3.00	—3.62	+.62
1791.3	7.73	7.05	—.68
1822.5	8.67	8.53	—.14
1828.5	9.12	8.69	—.43
1838.0	8.29	8.85	+.56
1866.5	8.37	8.60	+.23
1874.2	8.64	8.36	—.28
1880.9	7.94	8.08	+.14
1882.9	—7.90	—7.99	+.09
2.—VERA CRUZ, MEX.			
1727.0	—2.25	—2.92	+.67
1769.4	6.57	6.53	—.04
1776.5	7.50	7.10	—.40
1815.5	10.62	9.17	—1.45
1819.3	9.27	9.24	—.03
1839.5	8.37	9.18	+.81
1856.6	8.28	8.57	+.29
1861.0	8.33	8.33	.00
1880.1	—7.44	—7.02	—.42
3.—CITY OF MEXICO, MEX.			
1769.7	—5.46	—6.01	+.55
1775.5	6.70	6.33	—.37
1804.0	8.13	7.70	—.43
1849.5	8.50	8.62	+.12
1850.5	8.59	8.62	+.03
1856.9	8.77	8.58	—.19
1858.5	8.37	8.56	+.19
1860.5	8.50	8.54	+.04
1862.5	8.46	8.52	+.06
1867.0	8.15	8.44	+.29
1868.5	8.17	8.41	+.24
1879.8	8.58	8.12	—.46
1884.3	—8.32	—7.98	—.34
4.—SAN BLAS, MEX.			
1714.9	—0.50	—1.16	+.66
1788.2	—5.00	—6.11	+1.11
SAN BLAS, MEX.—continued.			
	°	°	°
1791.3	—7.47	—6.39	—1.08
1822.0	8.67	8.54	—.13
1837.5	8.85	9.19	+.34
1838.5	8.79	9.22	+.43
1839.5	9.00	9.25	+.25
1841.5	9.20	9.30	+.10
1874.1	9.14	9.18	+.04
1880.9	—9.30	—8.94	—.36
5.—SAN LUCAS, LOWER CAL.			
1709.0	—2.50	—2.40	—.10
1714.8	1.50	2.30	+.80
1779.9	6.00	4.63	—1.37
1839.5	8.63	8.78	+.15
1841.5	7.88	8.88	+1.00
1873.3	10.50	9.62	—.88
1875.0	9.65	9.61	—.04
1888.1	—9.44	—9.56	+.12
6.—MAGDALENA BAY, LOWER CAL.			
1714.8	—1.50	—2.17	+.67
1783.3	6.78	5.19	—1.59
1837.5	8.27	9.35	+1.08
1839.5	9.25	9.46	+.21
1866.4	10.67	10.43	—.24
1871.3	11.00	10.49	—.51
1873.3	10.56	10.50	—.06
1881.1	—10.48	—10.47	—.01
7.—CERROS ISLAND, MEX.			
1714.8	—1.75	—3.09	+1.34
1783.3	8.43	7.64	—.79
1839.5	10.90	11.47	+.57
1873.4	11.90	11.96	+.06
1875.0	12.15	11.94	—.21
1881.2	11.98	11.83	—.15
1888.3	—11.66	—11.63	—.03
8.—EL PASO, TEX.			
	°	°	°
1852.5	—12.40	—12.36	—.04
1859.1	12.42	12.46	+.04
1878.5	12.42	12.30	—.12
1884.3	12.08	12.13	+.05
1888.9	—11.90	—11.95	+.05
9.—SAN DIEGO, CAL.			
1714.8	—6.00	—7.33	+1.33
1783.3	10.44	9.30	—1.14
1792.5	11.00	9.82	—1.18
1839.5	12.34	12.32	—.02
1851.3	12.48	12.77	+.29
1853.8	12.53	12.85	+.32
1866.4	13.16	13.16	.00
1872.9	13.32	13.26	—.06
1881.3	13.46	13.32	—.14
1888.5	—13.07	—13.31	+.24
10.—SANTA BARBARA, CAL.			
1714.8	—7.50	—8.19	+.69
1783.3	11.36	10.58	—.78
1793.8	10.25	11.23	+.98
1839.5	13.47	13.88	+.41
1869.9	15.20	14.78	—.42
1881.3	—14.87	—14.80	—.07
11.—MONTEREY, CAL.			
1783.3	—12.44	—11.53	—.91
1786.7	11.80	11.69	—.11
1791.7	10.93	11.92	+.99
1792.9	12.37	11.98	—.39
1794.9	12.37	12.07	—.30
1837.5	14.50	14.32	—.18
1839.5	14.22	14.42	+.20
1841.5	15.00	14.52	—.48
1843.5	14.00	14.61	+.61
1851.1	14.97	14.96	—.01
1854.4	14.98	15.10	+.12
1873.7	15.92	15.75	—.17
1881.3	—15.90	—16.04	+.14

GROUP III.—*Comparison of observed and computed Magnetic Declinations*—Continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
12.—SAN FRANCISCO, CAL.			
	°	°	°
1783.3	—12.91	—12.80	— .11
1792.9	12.80	13.23	+ .43
1818.7	15.00	14.47	— .53
1827.5	15.45	14.89	— .56
1829.9	14.92	14.99	+ .07
1830.5	14.85	15.02	+ .17
1837.5	15.17	15.31	+ .14
1839.5	15.33	15.40	+ .07
1841.9	15.50	15.50	.00
1850.0	15.68	15.80	+ .12
1852.3	15.48	15.87	+ .39
1858.4	15.88	16.06	+ .18
1866.5	16.42	16.27	— .15
1871.9	16.38	16.39	+ .01
1872.8	16.43	16.40	— .03
1873.7	16.41	16.42	+ .01
1874.0	16.45	16.43	— .02
1879.2	16.57	16.50	— .07
1880.8	16.56	16.52	— .04
1881.5	16.48	16.53	+ .05
1883.4	16.64	16.54	— .10
1884.7	16.54	16.56	+ .02
1885.6	16.56	16.56	.00
1886.3	16.55	16.57	+ .02
1887.9	16.56	16.58	+ .02
1888.4	16.57	16.58	+ .01
1889.3	—16.60	16.58	— .02
13.—CAPE MENDOCINO, CAL.			
1783.3	—14.17	—14.36	+ .19
1786.7	14.90	14.51	— .39
1792.3	15.78	14.77	—1.01
1794.7	13.88	14.88	+1.00
1854.3	16.93	17.30	+ .37
1886.3	—18.01	—17.70	— .31
14.—SALT LAKE CITY, UTAH.			
1850.5	—15.57	—16.05	+ .48
1866.6	16.50	16.60	+ .10
1869.4	16.61	16.64	+ .03
1872.5	—17.02	—16.65	— .37
SALT LAKE CITY, UTAH—continued.			
	°	°	°
1878.7	—16.77	—16.60	— .17
1881.4	16.47	16.55	+ .08
1883.9	16.24	16.49	+ .25
1884.8	16.23	16.46	+ .23
1885.9	16.49	16.42	— .07
1887.9	—16.51	—16.36	— .15
15.—VANCOUVER, WASH.			
1788.6	—14.57	—16.05	+1.48
1839.5	19.37	19.57	+ .20
1859.5	21.50	20.60	— .90
1860.5	20.08	20.64	+ .56
1881.8	—20.89	—21.05	+ .16
16.—WALLA WALLA, WASH.			
1853.0	—20.51	—20.50	— .01
1860.5	20.25	20.78	+ .53
1861.5	21.34	20.81	— .53
1881.7	21.42	21.10	— .32
1889.7	—21.17	—21.05	— .12
17.—CAPE DISAPPOINTMENT, WASH.			
1783.3	—16.39	—17.15	+ .76
1786.7	18.00	17.24	— .76
1792.3	18.00	17.42	— .58
1839.5	19.18	19.75	+ .57
1842.5	20.00	19.91	— .09
1851.5	20.32	20.39	+ .07
1858.5	21.00	20.73	— .27
1873.8	21.44	21.37	— .07
1881.8	—21.60	—21.61	+ .01
18.—SEATTLE, DUWAMISH BAY, WASH.			
1783.3	—16.75	—16.80	+ .05
1855.5	21.42	21.65	+ .23
1871.8	22.59	22.21	— .38
1881.8	22.04	22.33	+ .29
1888.5	—22.48	—22.30	— .18
19.—PORT TOWNSEND, WASH.			
	°	°	°
1783.3	—17.00	—16.96	— .04
1841.5	20.67	20.98	+ .31
1856.6	21.66	21.63	— .03
1857.5	21.77	21.64	— .13
1862.5	22.00	21.75	— .25
1876.1	21.98	21.82	— .16
1881.9	—21.45	—21.75	+ .30
20.—NEE-AH BAY, CAPE FLATTERY, WASH.			
1783.3	—17.25	—17.45	+ .20
1792.3	18.00	17.87	— .13
1841.5	22.50	21.13	—1.37
1852.6	21.50	21.78	+ .28
1855.6	21.80	21.93	+ .13
1881.8	—22.74	—22.72	— .02
21.—NOOTKA SOUND, VANCOUVER IS'D.			
1778.2	—19.75	—18.76	— .99
1783.3	17.91	18.91	+1.00
1786.6	19.78	19.02	— .76
1792.8	18.37	19.27	+ .90
1860.5	23.78	23.07	— .71
1863.5	23.08	23.21	+ .13
1881.7	—23.60	—23.81	+ .21
22.—CAPTAIN'S AND ILIULIUK HARBORS, UNALASHKA.			
1790.4	—19.58	—19.00	— .58
1792.5	19.00	19.07	+ .07
1817.5	19.40	19.70	+ .30
1827.6	19.83	19.81	— .02
1831.5	19.50	19.83	+ .33
1849.5	20.00	19.72	— .28
1867.7	19.79	19.33	— .46
1870.5	19.75	19.25	— .50
1873.5	19.06	19.15	+ .09
1874.7	18.71	19.12	+ .41
1880.6	18.63	18.91	+ .28
1883.7	—18.71	—18.80	+ .09

Group III.—*Comparison of observed and computed Magnetic Declinations*—**Continued.**

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
23.—SITKA, ALASKA.			
	°	°	°
1779.5	—23.50	—24.89	+1.39
1786.5	26.77	25.40	—1.37
1787.4	24.00	25.47	+1.47
1791.6	27.77	25.79	—1.98
1804.6	26.75	26.74	— .01
1818.5	27.25	27.67	+ .42
1824.5	27.50	28.02	+ .52
1827.5	28.83	28.19	— .64
1829.9	28.31	28.31	.00
1838.6	28.62	28.68	+ .06
1842.6	28.54	28.81	+ .27
1843.5	28.90	28.84	— .06
1844.5	28.96	28.86	— .10
1845.5	29.00	28.89	— .11
1847.7	28.98	28.94	— .04
1848.5	29.08	28.96	— .12
1849.1	29.06	28.97	— .09
1850.5	28.84	29.00	+ .16
1851.5	28.88	29.01	+ .13
1852.4	28.81	29.03	+ .22
1856.5	28.98	29.07	+ .09
1857.5	29.12	29.08	— .04
1858.5	29.18	29.08	— .10
1859.5	29.10	29.09	— .01
1860.5	29.13	29.09	— .04
1861.5	29.07	29.09	+ .02
1862.5	29.02	29.09	+ .07
1863.5	29.06	29.08	+ .02
1864.5	29.07	29.08	+ .01
1867.6	28.82	29.05	+ .23
1874.3	28.99	28.93	— .06
1876.1	28.34	28.90	+ .56
1879.3	—28.90	—28.81	— .09
SITKA, ALASKA—continued.			
	°	°	°
1880.4	—29.08	—28.77	— .31
1881.7	—29.19	—28.73	— .46
24.—ST. PAUL, KADIAK IS'D, ALASKA.			
1778.4	—22.10	—23.18	+1.08
1790.5	25.50	24.58	— .92
1804.6	26.12	25.95	— .17
1808.5	25.75	26.27	+ .52
1818.5	26.50	26.90	+ .40
1834.5	28.63	27.38	—1.25
1839.5	26.72	27.38	+ .66
1845.5	27.00	27.29	+ .29
1867.7	26.08	26.09	+ .01
1874.4	25.37	25.51	+ .14
1880.5	—25.15	—24.90	— .25
25.—PORT MULGRAVE, YAKUTAT BAY, ALASKA.			
1778.3	—23.80	—24.14	+ .34
1787.4	26.00	25.75	— .25
1791.5	26.67	26.46	— .21
1794.5	26.00	26.94	+ .94
1802.0	29.00	28.13	— .87
1823.5	30.50	30.74	+ .24
1874.4	29.97	30.32	+ .35
1880.5	—30.00	—29.64	— .36
26.—PORT ETCHES, ALASKA.			
1778.4	—23.62	—24.04	+ .42
1787.4	—26.25	—25.69	— .56
PORT ETCHES, ALASKA—continued.			
	°	°	°
1788.4	—25.00	—25.87	+ .87
1790.5	26.23	26.25	+ .02
1794.5	28.50	26.94	—1.56
1810.5	28.13	29.36	+1.23
1830.5	31.63	31.24	— .39
1837.7	31.63	31.53	— .10
1874.4	—29.16	—29.57	+ .41
27.—PORT CLARENCE, ALASKA.			
1827.5	—26.91	—26.90	— .01
1850.5	26.43	26.38	— .05
1854.5	26.00	26.08	+ .08
1879.5	23.02	22.98	— .04
1880.7	—22.75	—22.79	+ .04
28.—CHAMISSO IS'D, ALASKA.			
1826.5	—31.29	—31.24	— .05
1849.5	30.43	30.52	+ .09
1880.7	—26.82	—26.74	— .08
29.—PETROPAVLOVSK, KAMCHATKA.			
1779.5	— 6.31	— 6.27	— .04
1792.5	6.00	5.98	— .02
1804.7	5.49	5.51	+ .02
1827.6	4.07	4.21	+ .14
1837.7	3.45	3.54	+ .09
1849.5	2.62	2.75	+ .13
1854.5	3.67	2.43	—1.24
1866.5	1.42	1.70	+ .28
1876.6	— 1.15	— 1.18	+ .03

RESULTS FOR GROUP III—Continued.

Contents of columns: The third column gives the year of first observation; the fourth, the whole number of observations used in the discussion; the fifth, the probable error of an observation, and the sixth the resulting epoch of nearest *extreme easterly* declination and the amount of maximum deflection at that epoch. A minus sign indicates east declination, and the annual change about the present time is shown for four epochs, at intervals of five years; a plus sign indicates diminishing easterly declination, a minus sign the reverse motion.

Number.	Station.	Year of first observation.	Number of observations.	Probable error of an observation.	Epoch of eastern elongation.	Maximum declination at epoch.	Annual change in			
							1880.0	1885.0	1890.0	1895.0
				′		°	′	′	′	′
1	Acapulco.	1744	9	±20	1846	— 8.9	+2.6	+ 2.9	+ 3.2	+ 3.5
2	Vera Cruz.	1727	9	28	1828	— 9.3	+4.7	+ 4.9	+ 5.1	+ 5.2
3	City of Mexico.	1769	13	13	1848	— 8.6	+1.8	+ 2.1	+ 2.3	+ 2.5
4	San Blas.	1714	10	25	1856	— 9.5	+2.5	+ 2.9	+ 3.3	+ 3.7
5	Cape San Lucas.	1709	8	32	1872	— 9.6	+0.7	+ 1.2	+ 1.7	+ 2.1
6	Magdalena Bay.	1714	8	31	1875	—10.5	+0.5	+ 1.0	+ 1.4	+ 1.9
7	Cerros Island.	1714	7	20	1866	—12.0	+1.3	+ 1.7	+ 2.1	+ 2.5
8	El Paso.	1852	5	4	1864	—12.5	+1.6	+ 2.1	+ 2.6	+ 3.0
9	San Diego.	1714	9	36	1883	—13.4	—0.2	+ 0.1	+ 0.4	+ 0.8
10	Santa Barbara.	1714	6	24	1880	—14.8	0.0	+ 0.4	+ 0.7	+ 1.1
11	Monterey.	1783	13	19	1899	—16.1	—1.2	— 0.9	— 0.6	— 0.3
12	San Francisco.	1783	27	10	1893	—16.6	—0.7	— 0.4	— 0.2	+ 0.1
13	Cape Mendocino.	1783	6	37	1886	—17.7	—0.2	0.0	+ 0.3	+ 0.6
14	Salt Lake City.	1850	10	12	1873	—16.7	+1.1	+ 1.8	+ 2.5	+ 3.2
15	Vancouver.	1788	5	36	1883	—21.0	—0.3	+ 0.2	+ 0.8	+ 1.3
16	Walla Walla (and Wallula).	1853	5	17	1880	—21.1	0.0	+ 0.5	+ 1.0	+ 1.5
17	Cape Disappointment.	1783	9	23	1905	—21.9	—1.7	— 1.4	— 1.1	— 0.7
18	Seattle.	1783	5	16	1883	—22.3	—0.4	+ 0.2	+ 0.8	+ 1.3
19	Port Townsend.	1841	6	11	1872	—21.8	+0.9	+ 1.5	+ 2.0	+ 2.5
20	Nee-ah Bay.	1783	6	19	1887	—22.7	—0.7	— 0.2	+ 0.3	+ 0.8
21	Nootka.	1778	7	40	1898	—24.0	—1.5	— 1.0	— 0.6	— 0.2
22	Captain's and Iliuliuk Harbors.	1790	12	14	1834	—19.8	+2.1	+ 2.3	+ 2.4	+ 2.4
23	Sitka.	1779	35	21	1861	—29.1	+1.9	+ 2.3	+ 2.7	+ 3.1
24	St. Paul, Kadiak.	1778	11	31	1837	—27.4	+6.2	+ 6.6	+ 6.9	+ 7.2
25	Port Mulgrave.	1778	8	28	1847	—31.8	+7.2	+ 8.1	+ 8.8	+ 9.4
26	Port Etches.	1778	9	36	1843	—31.6	+8.5	+ 9.3	+ 9.9	+10.5
27	Port Clarence.	1827	5	15	1833	—27.0	+9.5	+10.0	+10.4	+10.7
28	Chamisso Island.	1826	3	15	1830	—31.3	+9.4	+ 9.9	+10.2	+10.4
29	Petropavlovsk.	1779	9	16	1771	— 6.3	+2.5	+ 2.2	+ 1.8	+ 1.3

RESULTS FOR GROUP III, WESTERN SERIES—Completed.

Tabular values of magnetic declinations. Computed magnetic declination at each station for every tenth year of the series, and after 1850 for every fifth year. A minus sign signifies east declination, a plus sign west declination. The *first* tabular result for any station indicates that the first observation made there falls between the tabular date and the next one following it.

Year (January 1).	1. Acapulco, Mexico.	2. Vera Cruz, Mexico.	3. City of Mexico, Mexico.	4. San Blas, Mexico.	5. Cape San Lucas, Mexico.	6. Magdalena Bay, Lower California.	7. Cerros Island, Mexico.	8. El Paso, Tex.	9. San Diego, Cal.	10. Santa Barbara, Cal.
	°	°	°	°	°	°	°	°	°	°
1700	----	----	----	----	—2.6	----	----	----	----	----
10				—1.0	2.4	— 2.2	— 3.0		— 7.4	— 8.2
20		—2.4		1.3	2.3	2.2	3.3		7.4	8.2
30		3.2		1.7	2.3	2.3	3.7		7.4	8.3
40	—3.3	—4.0		—2.3	—2.5	— 2.5	— 4.3		— 7.6	— 8.5
1750	—4.0	—4.8	----	—3.0	—2.9	— 3.0	— 5.0	----	— 7.9	— 8.9
60	4.8	5.7	—5.4	3.8	3.4	3.5	5.7		8.2	9.3
70	5.6	6.6	6.0	4.6	4.0	4.2	6.5		8.7	9.8
80	6.3	7.4	6.6	5.4	4.6	4.9	7.4		9.2	10.4
90	—7.0	—8.0	—7.1	—6.3	—5.4	— 5.7	— 8.2		— 9.7	—11.0
1800	—7.6	—8.6	—7.5	—7.1	+6.2	— 6.6	— 9.0	----	—10.3	—11.6
10	8.1	9.0	7.9	7.8	6.9	7.4	9.8		10.8	12.3
20	8.5	9.3	8.2	8.43	7.6	8.2	10.5		11.4	12.9
30	8.7	9.3	8.5	8.92	8.26	8.9	11.0		11.9	13.43
40	—8.9	—9.2	—8.6	—9.26	—8.81	— 9.49	—11.5		—12.35	—13.90
1850	—8.88	—8.86	—8.62	—9.44	—9.23	— 9.97	—11.81	—12.31	—12.73	—14.30
55	8.83	8.64	8.59	9.47	9.38	10.15	11.91	12.41	12.89	14.46
60	8.75	8.39	8.55	9.45	9.50	10.30	11.98	12.47	13.03	14.60
65	8.64	8.10	8.48	9.40	9.56	10.41	12.01	12.48	13.14	14.70
70	—8.50	—7.77	—8.39	—9.29	—9.62	—10.47	—12.00	—12.45	—13.22	—14.78
1875	—8.33	—7.41	—8.26	—9.15	—9.61	—10.50	—11.95	—12.38	—13.28	—14.82
80	8.12	7.03	8.13	8.97	9.57	10.48	11.86	12.26	13.31	14.84
85	7.89	6.63	7.96	8.76	9.49	10.42	11.74	12.11	13.32	14.82
90	7.64	6.21	7.77	8.50	9.37	10.32	11.58	11.91	13.29	14.8
95	—7.4	—5.8	—7.6	—8.2	—9.21	—10.2	—11.4	—11.7	—13.2	—14.7
1900	—7.1	—5.3	—7.4	—7.9	—9.0	—10.0	—11.2	—11.4	—13.2	—14.6

The values for 1900 are rough predictions.

RESULTS FOR GROUP III, WESTERN SERIES—Completed.

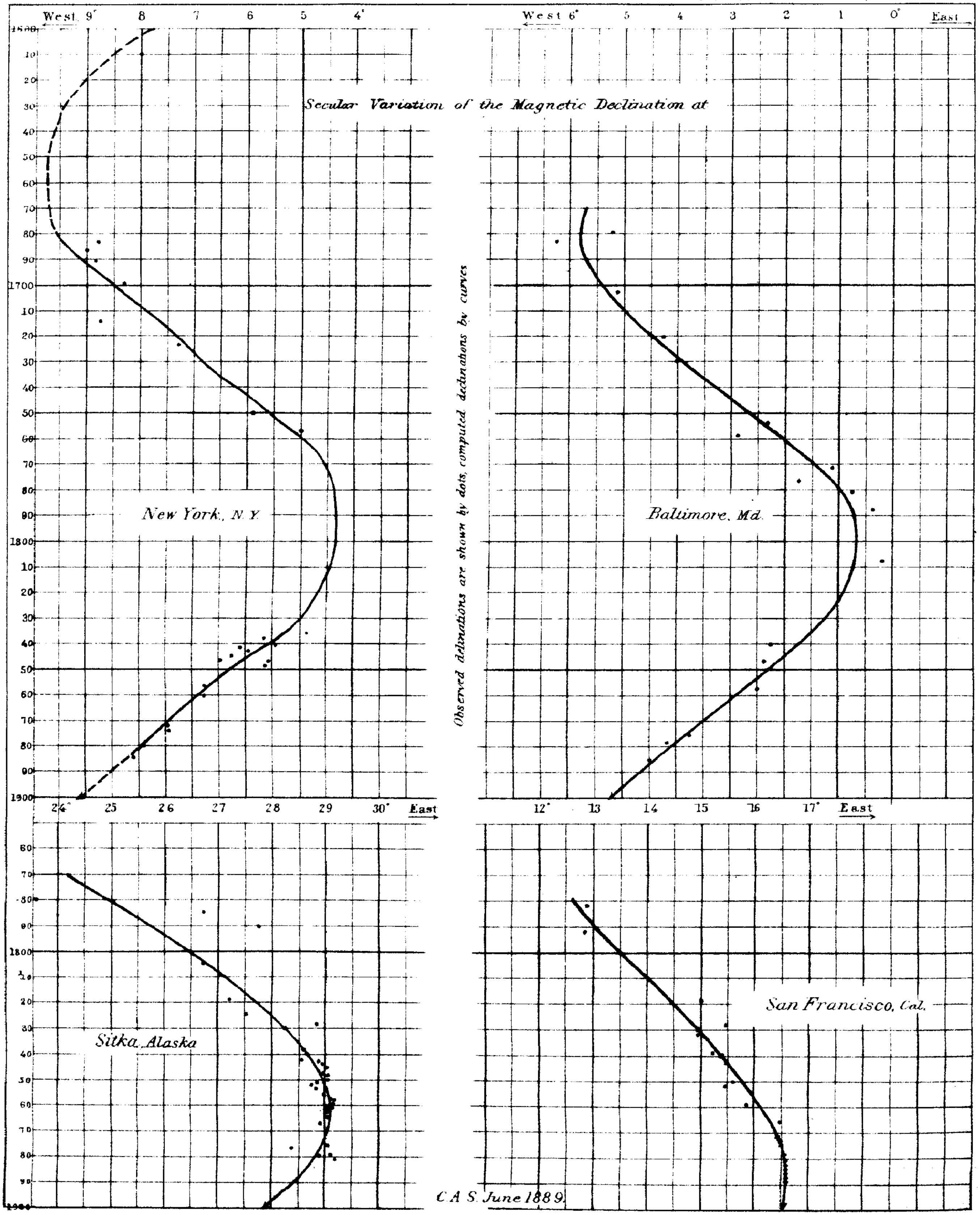
Year (January 1).	11. Monterey, Cal.	12. San Francisco, Cal.	13. Cape Mendocino, Cal.	14. Salt Lake City, Utah.	15. Vancouver, Wash.	16. Walla Walla, Wash.	17. Cape Disappointment, Wash.	18. Seattle, Duwamish Bay, Wash.	19. Port Townsend, Wash.	20. Nee-ah Bay, near Cape Flattery, Wash.
	°	°	°	°	°	°	°	°	°	°
1700	----	----	----	----	----	----	----	----	----	----
10										
20										
30										
40										
1750	----	----	----	----	----	----	----	----	----	----
60										
70										
80	—11.4	—12.6	—14.2		—15.6		—17.1		—16.8	—17.3
90	—11.8	—13.1	—14.7		—16.1		—17.3		—17.4	—17.8
1800	—12.33	—13.6	—15.1	----	—16.8	----	—17.7	----	—18.1	—18.3
10	12.86	14.1	15.6		17.5		18.2		18.8	18.9
20	13.40	14.54	16.0		18.2		18.7		19.6	19.6
30	13.93	15.00	16.5		18.9		19.2		20.3	20.3
40	—14.45	—15.42	—16.9		—19.6		—19.8		—20.9	—21.0
1850	—14.91	—15.79	—17.2	—16.0	—20.17	—20.4	—20.31	—21.3	—21.38	—21.64
55	15.13	15.96	17.3	16.3	20.41	20.6	20.56	21.6	21.57	21.90
60	15.32	16.10	17.4	16.45	20.62	20.8	20.80	21.8	21.70	22.13
65	15.49	16.23	17.5	16.58	20.78	20.9	21.02	22.0	21.79	22.33
70	—15.65	—16.34	—17.6	—16.64	—20.91	—21.0	—21.22	—22.13	—21.83	—22.50
1875	—15.78	—16.44	—17.6	—16.64	—21.00	—21.1	—21.40	—22.23	—21.83	—22.62
80	15.89	16.51	17.69	16.58	21.04	21.1	21.56	22.28	21.78	22.70
85	15.98	16.56	17.70	16.45	21.05	21.1	21.69	22.29	21.68	22.74
90	16.04	16.58	17.69	16.3	21.0	21.0	21.79	22.25	21.54	22.73
95	—16.1	—16.59	—17.7	—16.0	—20.9	—20.9	—21.9	—22.2	—21.3	—22.7
1900	—16.1	—16.57	—17.6	—15.7	—20.8	—20.8	—21.9	—22.1	—21.1	—22.6

The values for 1900 are rough predictions.

RESULTS FOR GROUP III, WESTERN SERIES—Completed.

Year (January 1).	21. Nootka, Vancouver Island.	22. Captain's and Iliuliuk Harbors, Unalashka Island.	23. Sitka, Alaska.	24. St. Paul, Kadiak Island.	25. Port Mulgrave, Yakutat Bay, Alaska.	26. Port Etches, Alaska.	27. Port Clarence, Alaska.	28. Chamisso Island, Kotzebue Sound.	29. Petropavlovsk, Kamchatka, Siberia.
	°	°	°	°	°	°	°	°	°
1700	----	----	----	----	----	----	----	----	----
10									
20									
30									
40									
1750	----	----	----	----	----	----	----	----	----
60									
70	—18.6		—24.2	—22.2	—22.7	—22.5			—6.3
80	18.8	—18.6	24.9	23.4	24.5	24.4			6.26
90	—19.2	—19.0	—25.7	—24.5	—26.2	—26.16			—6.06
1800	—19.6	—19.32	—26.41	—25.54	—27.82	—27.84	----	----	—5.72
10	20.1	19.56	27.12	26.37	29.25	29.28			5.25
20	20.7	19.73	27.76	26.98	30.41	30.44	—26.6	—31.1	4.69
30	21.3	19.82	28.31	27.32	31.24	31.22	27.0	31.3	4.06
40	—22.0	—19.75	—28.72	—27.38	—31.71	—31.58	—26.9	—31.1	—3.39
1850	—22.54	—19.71	—28.99	—27.15	—31.78	—31.50	—26.4	—30.5	—2.72
55	22.80	19.63	29.06	26.93	31.66	31.30	26.0	30.1	2.40
60	23.05	19.53	29.09	26.65	31.45	30.99	25.6	29.6	2.08
65	23.27	19.41	29.08	26.31	31.14	30.59	25.0	29.0	1.79
70	—23.47	—19.27	—29.02	—25.90	—30.74	—30.09	—24.4	—28.3	—1.51
1875	—23.63	—19.11	—28.92	—25.45	—30.26	—29.49	—23.7	—27.6	—1.26
80	23.77	18.94	28.79	24.96	29.69	28.8	22.9	26.8	1.03
85	23.88	18.75	28.6	24.4	29.06	28.1	22.1	26.0	0.84
90	23.95	18.56	28.4	23.9	28.4	27.3	21.2	25.2	0.7
95	—24.0	—18.4	—28.2	—23.3	—27.6	—26.4	—20.4	—24.3	—0.6
1900	—24.0	—18.2	—27.9	—22.7	—26.8	—25.5	—19.5	—23.5	—0.5

The values for 1900 are rough predictions.


Secular Variation of the Magnetic Declination at
New York, N. Y.
Baltimore, Md.
Sitka, Alaska
San Francisco, Cal.
Observed declinations are shown by dots, computed declinations by curves
West 9° 8 7 6 5 4°
West 6° 5 4 3 2 1 0° East
24° 25 26 27 28 29 30° East
12° 13 14 15 16 17° East
1600
1700
1800
1900
C A S. June 1889.

GRAPHICAL ILLUSTRATION OF THE SECULAR VARIATION AND OF THE ANNUAL CHANGE.

In a preceding part of this paper we have already made use of the graphical method to exhibit to the eye the motion of the needle as observed at Paris, and since this kind of representation has the great advantage of readily impressing the facts on the memory and of affording easy comparisons and generalizations, the secular motion as observed at four leading stations is introduced on plate No. 22. These stations are New York, Baltimore, San Francisco, and Sitka. As an aid to mnemonics, the degrees of easterly declination are shown on the diagrams to increase toward the right or east, and consequently the degrees of westerly declination increase toward the left or west, the ordinates being considered as directed north and south (true); the time scale increases downward where additional observations can be plotted more conveniently than on the top. The observed declinations are shown by dots, the computed declinations by a continuous curved line. These diagrams show in a conspicuous manner the great regularity and persistency of the secular variation, and thus impress the mind with the fact that the explanation of it must ultimately be referred to forces of a periodic character having their origin outside the earth and acting simultaneously over large areas and with great regularity, and probably having their immediate source directly or indirectly in the sun, with a probable dependence on planetary configurations. The effect of these deflecting forces on the magnetic condition at points on the earth's surface is subject to great modifications as manifested in the observed variations in the amplitude and in the duration of the secular oscillation at places which, geographically, are widely distributed. At the present time we are not yet in possession of any theory or even of a plausible working hypothesis as to the true cause or origin of the secular variation, and are consequently constrained to pursue our researches empirically through the aid of continued observations and new discussions.

On plate No. 25 we give the annual change of the declination for the epoch 1890, for all places discussed and falling within its limits. The numbers are expressed in minutes of arc, and are directly taken from the preceding tables. A plus sign indicates increasing west or decreasing east declination, as the case may be. In order to know where the declination is west and where it is east, the agonic line (or line of no deviation connecting the places where the magnetic and geographic meridians coincide) for 1890 is introduced; for all places to the right, or to the northward and eastward of this line, the declination is west at that epoch, and for all places to the left, or to the south and west of it, it is east at that time. The plate also shows the positions of this agonic line for the epoch 1797–1803, about which time it had about reached on this coast its extreme northeastern position, having come up from the southward; apparently it rested here a few years and then commenced to retreat over part of its previous course. At that time, in this vicinity, it passed between Washington and Baltimore, and extended out to sea just south of Cape Henry, Va. It is not easy, however, to determine the exact time when this stationary condition happened; there may be an uncertainty of several years in consequence of the ordinary irregularities in the direction of the needle and the extreme smallness of the secular effect, which is overlaid and hidden by the former; besides, the same year will not answer for all parts of the curve. The plate shows also the positions of the agonic line for the epochs 1850 and 1875, and it is hardly necessary to remark that while about 1797 its geographical change was *nil*, its rate of change southward along our Atlantic coast has continually been accelerated, and it will reach a maximum speed at the time of the middle of the secular swing. It will be noticed also that for nearly the whole of the United States and for 1890 the annual change has a positive sign; in other words, the north end of the needle moves westward, increasing west or diminishing east declination, and the same is true for Alaska; but there are two regions of exception where the opposite of this motion is observed, viz, one in the extreme northeast, outside of our territory, in Newfoundland and part of Nova Scotia, the other in the extreme west, which is less accurately known than the other and comprises a narrow strip along the coast of northern California, Oregon, and Washington. Shaded bands on the plate indicate the position of those regions for 1890, where the needle will have apparently ceased to move, or will have assumed, temporarily, a stationary condition; *western* elongation or maximum west declination having been reached at all places within the Nova Scotia belt, and *eastern* elongation or maximum east declination at all places within the Pacific coast belt. These bands, like the agonic line or any other isogonic curve, continually and gradually shift their position, to which circumstance we shall presently recur. The condition of the horizontal needle within these belts may be characterized as being in opposite phases as regards the secular variation. It would not be difficult to construct curves of *equal annual change* for any given epoch, as was done by the writer for a limited area (Coast Survey Report for 1865, plate No. 28), in which system the above belts would form the zero lines, but the subject is sufficiently plain without such aid, and the existing scanty material does not warrant such detailed exposition. The line of maximum annual change might be expected to lie geographically midway between the two zero regions, which we find roughly to be the case. If we follow up the direction of the *eastern* or Nova Scotia band of present "zero" annual change we shall find it to cross the equator and to pass toward the southwestern coast of Africa; the *western* or Washington, Oregon, and California band of "zero" annual change, when produced southwards, will also cross the equator, and roughly running parallel† with the Atlantic belt will follow the direction of the South American coast towards Cape Horn.

The following table of the annual change of the magnetic declination is derived, simply, from a generalization of the preceding results; it answers for the epoch 1890 and refers to the central part of each State, Territory, or geographical subdivision. The change is given in minutes and its sign is omitted since we know west declination to be increasing or east declination decreasing:

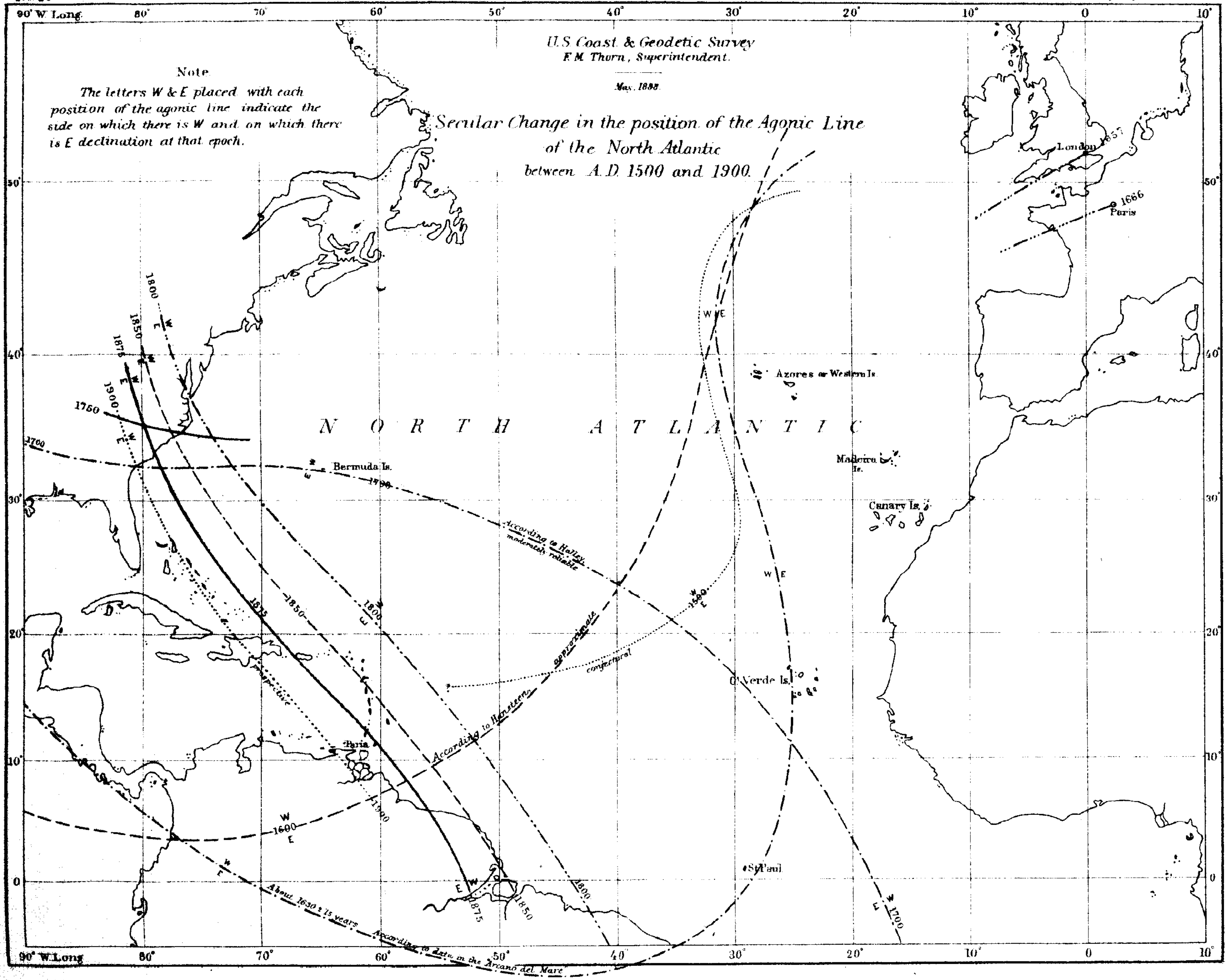
	′		′
Alabama.	3.5	Mississippi.	3.7
Alaska T.:		Missouri.	4.2
Dixon Entrance.	1 (?)	Montana.	2 (?)
Sitka Bay.	3 (?)	Nebraska:	
Off Mt. St. Elias.	9 (?)	Western part.	3 (?)
Arizona T.	2 (?)	Eastern part.	4 (?)
Arkansas.	3.3	Nevada.	2 (?)
California:		New Hampshire.	3.4
Northern part.	0.5 (?)	New Jersey.	3.5
Southern part.	0.7 (?)	New Mexico T.	2.7
Colorado.	2.9	New York:	
Connecticut.	3.7	Long Island.	3.3
Delaware.	3.3	Main part.	3.9
District of Columbia.	3.1	North Carolina.	3.3
Florida:		North Dakota.	3 (?)
Northwestern part.	3.6	Ohio.	3.3
Peninsula.	3.4	Oregon:	
Georgia.	3.6	Western part.	0.0
Idaho T.	2 (?)	Eastern part.	1.5 (?)
Illinois.	4.0	Pennsylvania.	3.9
Indiana.	3.8	Rhode Island.	3.4
Indian T.	3.0	South Carolina.	3.2
Iowa.	4.4	South Dakota.	4 (?)
Kansas.	3.3	Tennessee.	3.5
Kentucky.	3.5	Texas:	
Louisiana.	3.4	Northwest part.	2.8
Maine:		Western part.	2.6
Western part.	2.5	Main part.	3 (?)
Eastern part.	1.0	Utah T.	2.5
Maryland.	3.1	Vermont.	4.3
Massachusetts:		Virginia.	3.2
Western part.	3.7	Washington:	
Eastern part.	2.2	Western part.	0.0
Michigan:		Eastern part.	1.2
Southern part.	4 (?)	West Virginia.	3.3
Northwestern part.	3 (?)	Wisconsin.	3.5 (?)
Minnesota.	3.5 (?)	Wyoming T.	3 (?)

SECULAR VARIATION IN THE POSITION OF THE AGONIC LINE OF THE NORTH ATLANTIC AND OF AMERICA BETWEEN THE EPOCHS 1500 AND 1900 A. D.*

As an historical fact since the time of Columbus and the Cabots, and thus reaching back to a period prior to the year 1500, there were found in the Atlantic Ocean places where the needle, for

* This article was published June 7, 1888, as Bulletin No. 6.

† As on Mercator's projection.


U.S. Coast & Geodetic Survey
F. M. Thorn, Superintendent.
May, 1888.
Secular Change in the position of the Agonic Line
of the North Atlantic
between A.D. 1500 and 1900.
Note.
The letters W & E placed with each position of the agonic line indicate the side on which there is W and on which there is E declination at that epoch.
N O R T H A T L A N T I C
Bermuda Is.
Azores or Western Is.
Madeira Is.
Canary Is.
C. Verde Is.
St. Paul
London
Paris
1657
1666
1700
1760
1800
1850
1875
1900
1600
1500
According to Halley, moderately reliable
approximate
conjectural
According to Hansteen
prospective
About 1630 ± 15 years. According to data in the Arcano del Mare
90° W. Long.
80°
70°
60°
50°
40°
30°
20°
10°
0
10°

the time being, pointed due north and south. By uniting such places as represented on a chart, by a curve drawn through them with a free hand, we obtain a so-called agonic line which passes over all places of no angular deviation of the needle at that particular epoch, and within the geographical limit of the region under consideration. Such a line is part of a system of isogonic curves, and although only an artificial aid, like these curves, it possesses, nevertheless, some special interest as a convenient representative for exhibiting the secular movement or systematic changes in time of the isogonic system in its vicinity.

For the two centuries immediately following the re-discovery of America, the magnetic records which have come down to us are very few, rough, and the positions are scattered over large spaces, so that the location of the agonic line for A. D. 1500, attempted by me, is little more than a conjecture, and depends mainly on the position of two points in the line, the first one found by Columbus, September 13, 1492, when he notes the needle to have passed from the east to the west of the true meridian. At noon on that day he was, according to my calculation of his track,* in latitude 28° 21′ and longitude 29° 16′. The second point lies further north and is due to Sebastian Cabot,† and dates from 1497 or 1498; he found, when on the meridian 110 miles west of the island of Flores, one of the Azores, and in latitude approximately 46° or 47°, that he was in a position where the needle had "no variation." We have further reason to suppose that this agonic line produced passed somewhere north of London, and at its other extremity at some distance south of the Greater Antilles, as shown on plate No. 20, accompanying.

The next position given is for A. D. 1600; it is copied from Hansteen, and as his authorities for it have already been referred to in connection with our inquiry of the value of the "Arcano del Mare" of Robert Dudley,‡ no further comment is needed here. For the position of the agonic line about the time 1630 ± 15 years, we simply have to refer to our detailed account when investigating the contents of the Arcano, upon the authority of which it wholly rests. Coming now to the year 1700, we possess the admirable isogonic chart of Halley, based upon observations made or collected by himself. However well the distribution of the declination along our Atlantic coast may be given on this chart, we believe the curves over the Antilles and of the Gulf of Mexico and Central America to be susceptible of improvement, as already intimated. The data at our command for this epoch are sufficiently numerous, yet many are deficient in accuracy or unreliable. To test the value of this material and to give greater precision to the isogonic curves in the vicinity of our

*For particulars see two papers in Coast and Geodetic Survey Report for 1880, viz: Appendix No. 18: "An attempt to solve the problem of the first landing place of Columbus in the New World," by Capt. G. V. Fox, Assistant Secretary of the Navy, 1861–'66; and Appendix No. 19: "An inquiry into the variation of the compass off the Bahama Islands at the time of the land-fall of Columbus in 1492," by Charles A. Schott, Assistant. In connection with this subject it may be remarked *en passant* that, in the writer's opinion, the controversy about the first landing place and the track of Columbus among the West India Islands subsequent to it, may now be considered as closed (save the identification of the harbor first made in Cuba, which is of less interest) by the recent labors of Lieut. J. B. Murdock, U. S. N.: "The Cruise of Columbus in the Bahamas, 1492;" reprinted from No. 30 of the Proceedings of the U. S. Naval Institute, Annapolis, Md., April, 1884. The land-fall took place undoubtedly at Watling's Island, as insisted upon by Captain Becher, in 1856, but in attempting to trace the *subsequent* track he fell into an unfortunate error in consequence of the assumption of an extreme value of the magnetic declination, supposed by him to have prevailed at the time of Columbus's approach. The "*Bird Rock*" is the key to the track among the islands, and thence tracing the given courses and distances backwards, Watling's Island is readily and unmistakably reached as the first land seen.

†Soon after the discovery by Columbus of a point of no variation in the Atlantic, Sebastian Cabot discovered a second one farther north and evidently belonging to the same agonic curve. Livio Sanuto states, in his Geographica Distincta (Venice, 1588), that he procured the information from Sebastian Cabot and made use of his map (probably that composed in 1544), on which the position of the meridian intersecting the point of no variation was seen to be one hundred and ten miles to the *west* of the island of Flores, one of the Azores; see "Narrative and Critical History of America," by Justin Winsor, Vol. III, Boston and New York, 1884, p. 41. This discovery probably was made on the second voyage of the Cabots, in 1498, although it may have been noted in the first, in 1497, by the elder Cabot. The latitude of the point is uncertain, but may be approximated from the fact that in the first voyage land was apparently sighted at Cape Breton, and in the second the coast of Newfoundland (Baccalaos), which is said to have been made from the North.

In the course of a conversation with Contarini, the Venetian ambassador to Charles V, in 1522, Sebastian Cabot told the ambassador that he had a method for ascertaining, *by the needle*, the distance between two places from east to west, which had never previously been discovered by any one. *Ibid*, p. 50.

In this idea, however, he was also anticipated by Columbus.

‡ Bulletin No. 5, published June 7, 1888.

eastern coast, as well as to supply, by reliable interpolation, values of the declination at places where direct observations had otherwise to be supported (at least temporarily) in order to construct formulæ expressive of the secular variation for such places, I have made an attempt to express the distribution by the formula:

$$D=D_0+x.\triangle\varphi+y.\triangle\lambda\cos\varphi+z.\triangle\varphi^2+v.\triangle\lambda^2\cos^2\varphi+w.\triangle\varphi\triangle\lambda\cos\varphi,$$

where $\triangle\varphi=\varphi-\varphi_0$ or the difference of latitude of a magnetic station from the mean or adopted latitude of all stations, $\triangle\lambda=\lambda-\lambda_0$, the same with reference to longitude, $D_0=D_1+c$, the declination at φ_0, λ_0, where D_1=an assumed value and c its correction; then D=the declination (+ when west) is sufficiently expressed by the several terms given above; the 6 quantities, c, x, y, z, v, w, having been determined as usual by application of the method of least squares. The following 17 values, forming the basis of the calculation, were taken from Appendix No. 12, Coast and Geodetic Survey Report for 1886, or from the contents of the present paper:

No.	Name of station.	Latitude.	Longitude (west).	Declination.
		°	°	°
1	Saint John's, Newfoundland.	47.6	52.7	+15
2	Halifax, Nova Scotia.	44.7	63.6	+12
3	Quebec, Canada.	46.8	71.2	+16.5
4	Eastport, Me.	44.9	67.0	+13
5	Boston and Cambridge, Mass.	42.4	71.1	+10
6	Provincetown, Cape Cod, Mass.	42.1	70.2	+ 9.5
7	Nantucket, Mass.	41.3	70.1	+ 9
8	New York, N. Y.	40.7	74.0	+ 8.7
9	Philadelphia and Hatboro', Pa.	40.1	75.1	+ 8.1
10	Baltimore, Md.	39.3	76.6	+ 5.4
11	Cape Henlopen, Del.	38.8	75.1	+ 6
12	Williamsburg, Va.	37.3	76.7	+ 4.9
13	Cape Henry, Va.	36.9	76.0	+ 4.6
14	Charleston, S. C.	32.8	79.9	− 0.6
15	New Orleans, La.	30.0	90.1	− 2.5±1°
16	Havana, Cuba.	23.2	82.4	− 3 ±2
17	Kingston, Jamaica.	17.9	76.8	− 4 ±2

The probable errors for the values adopted for the last three stations are estimated, and indicate the weakest part of the available data.

Taking $\varphi_0=39°.3$ $\lambda_0=73°.2$ and $D_1=+7°.1$

The normal equations become:

$$\left\{\begin{array}{lllllll}
0=+\ 8.1 & +\underline{17\,c} & -\ 21.3\,x & +\ 10.9\,y & +\ 1065\,z & +\ 624\,v & -\ 595\,w \\
0=-\ 768 & & +\underline{1065\,x} & -\ 595\,y & -\ 13678\,z & -\ 1693\,v & +\ 3897\,w \\
0=+\ 518.5 & & & +\underline{624\,y} & +\ 3897\,z & +\ 1054\,v & -\ 1693\,w \\
0=+7416 & & & & +\underline{295941\,z} & +\ 59187\,v & -\ 92681\,w \\
0=+1341 & & & & & +\underline{90986\,v} & -\ 65181\,w \\
0=-2449 & & & & & & +\underline{59351\,w}
\end{array}\right.$$

Solving, we get: $c=-0.6912$, $x=+1.1377$, $y=+0.0833$,
$z=+0.0284$, $v=-0.0174$, $w=-0.0128$, and our expression becomes:

$$D_{1700}=+6°.409+1.138\triangle\varphi+0.083\triangle\lambda\cos\varphi+0.0284\triangle\varphi^2-0.0174\triangle\lambda^2\cos^2\varphi$$
$$-0.0128\triangle\varphi\triangle\lambda\cos\varphi.$$

The given and computed values compare as follows:

	Obs'd or given declination.	Comp'd declination.	O—C.		Obs'd or given declination.	Comp'd declination.	O—C.
	°	°	°		°	°	°
1. Saint John's.	+15	+14.9	+0.1	11. Cape Henlopen.	+6	+5.9	+0.1
2. Halifax.	+12	+12.5	—0.5	12. Williamsburg.	+4.9	+4.4	+0.5
3. Quebec.	+16.5	+16.5	0.0	13. Cape Henry.	+4.6	+4.0	+0.6
4. Eastport.	+13	+13.3	—0.3	14. Charleston.	—0.6	+0.6	—1.2
5. Boston and Camb.	+10	+10.1	—0.1	15. New Orleans.	—2.5	—2.5	0.0
6. Provincetown.	+ 9.5	+ 9.6	—0.1	16. Havana.	—3	—3.3	+0.3
7. Nantucket.	+ 9	+ 8.6	+0.4	17. Kingston.	—4	—3.9	—0.1
8. New York.	+ 8.7	+ 8.1	+0.6				+3.3
9. Phila. and Hatb.	+ 8.1	+ 7.4	+0.7			Check, Σ	—3.4
10. Baltimore.	+ 5.4	+ 6.5	—1.1				

Let r=probable error of an observation and representation by above formula, n=the number of observations or (indirectly) given declinations, and ν=the number of unknown quantities determined or the number of normal equations, then, putting δ for O—C, we have $r=0.674\sqrt{\frac{[\delta\delta]}{n-\nu}}$ $=\pm 0°.44$ or $\pm 26'$. The representation is therefore very close; the probable error of observation alone, it may be supposed, would cover about half a degree.

By means of our formula D_{1700}, the isogonic curves for $-3°$, $0°$, $+5°$, $+10°$, $+15°$, were laid down on the accompanying plate No. 23, the computed points of intersection being as follows:

	φ	λ		φ	λ		φ	λ		φ	λ		φ	λ
	°	°		°	°		°	°		°	°		°	°
−3°	26.7	75.2	0°	32.6	73.2	+5°	38.3	69.2	+10°	43.6	60.2	+15°	47.7	52.7
	25.7	79.2		32.0	80.2		38.0	73.2		42.4	69.2		46.7	59.2
	25.5	83.2		32.2	84.2		37.9	77.2		42.2	73.2		46.1	66.2
	27.9	88.2		34.2	90.2		38.6	83.2		42.3	78.2		45.8	73.2

These curves should not be extended beyond the limits given them on the plate, but the formula is available for all places within the general area covered by these curves; south of the strait of Florida the curves change their character in consequence of the near approach but opposite sign of the numerical values of the terms in $\triangle\varphi$ and in $\triangle\varphi^2$; which sets a southern limit to the use* of the expression for D_{1700}. It will be noticed that our curves and those of Halley agree well for west declination, also for east declination. I have already pointed out the difficulty of reconciling the observations made before 1700 with those after this epoch.

During the next half century but few additional stations become available, and there is no gain in accuracy in the observed values (taken as before from our investigation of the secular variation) for the 19 stations submitted to treatment; Charleston had to be omitted since $-3°.8$ for 1750 proved inadmissable; our present tabular value is $-3°.1$, and the value first computed was

* This limit was farther south (—5° was available) in our first attempt to establish an expression, when I had provisionally adopted the following observed or given values for New Orleans, Havana, and Kingston (—3°, —5°.5, —6°) respectively in the place of the values given above.

$-2^\circ.1$ St. John's was omitted for want of an observation. The treatment for the epoch 1750 is the same as that given for 1700. We have the following data and results:

No.	Station.	Obs'd decl'n.	Comp'd decl'n.	O—C.	
		°	°	°	
1	Halifax, N. S.	+12.8	+12.0	+0.8	
2	Montreal, Can.	10.7	10.3	+0.4	
3	Eastport, Me.	11.2	11.4	—0.2	$\left\{\begin{array}{l}\triangle\phi=\phi-38^\circ.2\\ \triangle\lambda=\lambda-74.6\end{array}\right.$
4	Portland, Me.	8.8	9.2	—0.4	
5	Boston and Cambridge, Mass.	7.5	7.8	—0.3	
6	Provincetown, Cape Cod.	6.6	7.7	—1.1	
7	Nantucket, Mass.	6.0	6.9	—0.9	
8	Providence, R. I.	7.8	7.1	+0.7	
9	New York, N. Y.	6.0	5.5	+0.5	$r=0.674\sqrt{\frac{8.21}{19-6}}=\pm 0^\circ.54$
10	Bethlehem, Pa.	6.1	5.0	+1.1	$=\pm 32'$
11	Phila. and Hatboro, Pa.	5.0	4.6	+0.4	
12	Chambersburg, Pa.	3.2	3.8	—0.6	
13	Baltimore, Md.	2.6	3.6	—1.0	
14	Cape Henlopen, Del.	2.8	3.5	—0.7	
15	Williamsburg, Va.	2.7	2.0	+0.7	
16	Cape Henry, Va.	+2.6	+1.8	+0.8	
17	New Orleans, La.	—4.7	—4.6	—0.1	
18	Havana, Cuba.	—5.5	—5.5	0.0	
19	Kingston, Jamaica.	—6.7	—6.7	0.0	

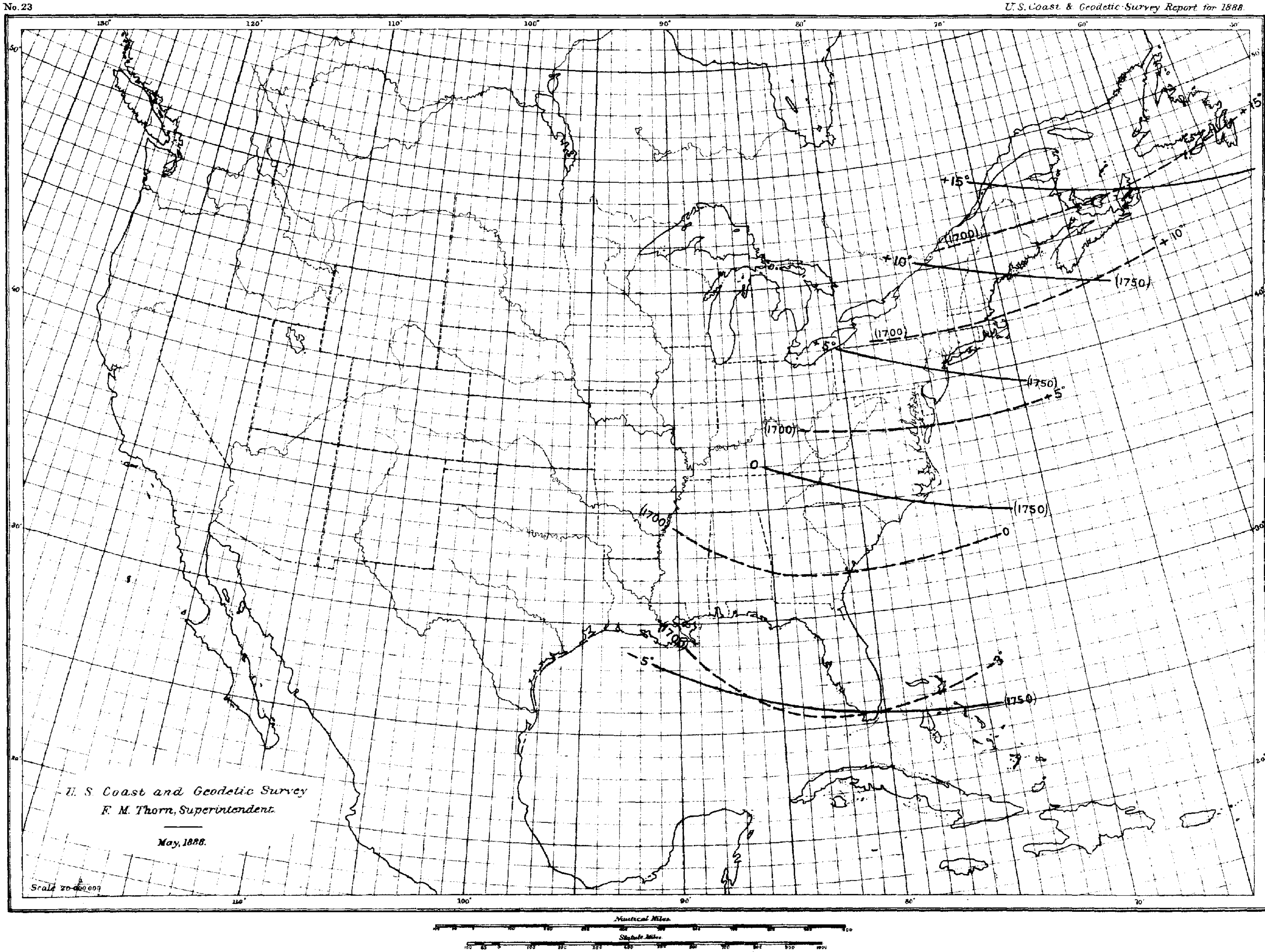
$$D_{1750}=+3^\circ.100+0.833\,\triangle\varphi-0.255\,\triangle\lambda\cos\varphi+0.0164\,\triangle\varphi^2-0.0052\,\triangle\lambda^2\cos^2\varphi$$
$$-0.0216\,\triangle\varphi\,\triangle\lambda\cos\varphi.$$

Intersections for constructing the isogonic curves:

	φ	λ		φ	λ		φ	λ		φ	λ		φ	λ
	°	°		°	°		°	°		°	°		°	°
-5°	25.2	74.6	0°	33.8	72.6	$+5^\circ$	39.3	69.6	$+10^\circ$	43.0	63.6	$+15^\circ$	45.5	53.0
	25.15	78.6		34.1	74.6		40.4	74.6		44.2	69.6		46.5	60.6
	25.9	83.6		35.1	78.6		41.2	77.6		45.4	74.6		48.4	69.0
	27.0	87.6		36.4	82.6		41.9	80.0						
	28.05	90.0		37.2	85.0									

The curves will be found laid down on the same plate (No. 23) which contains those for 1700; the change during half a century is thus directly exhibited.

For the epoch 1800 our material has become richer and precludes the need of such auxiliary expressions as those established for 1700 and 1750. The agonic line for 1800 depends on a graphical process after plotting a number of stations on both sides of the line and marking for each the observed or deduced declination at that epoch.


U. S. Coast and Geodetic Survey
F. M. Thorn, Superintendent.
May, 1888.
Scale 1/20,000,000
+15°
1750
(1700)
+10°
(1750)
+10
(1700)
+5°
(1750)
+5°
(1700)
0
(1750)
(1700)
0
5°
(1700)
-3°
(1750)
Nautical Miles.
Statute Miles.

Stations in the vicinity of the agonic line for 1800, as shown on plate No. 25, with date when the extreme value of the declination was reached and its amount:

Station.	Tabular declination in 1800.	Epoch of max. east or min. west.	Am't at epoch.
	°		°
Cape Henry.	+0.24	Min. 1810	+0.2
Williamsburg.	—0.17	Max. 1811	—0.3
Washington.	—0.1	Max. 1798	—0.3
Baltimore.	+0.64	Min. 1802	+0.6
Chambersburg.	—0.30	Max. 1809	—0.4
Huntingdon.	------	Max. 1793	—0.2
Harrisburg.	0.0	Extr. 1790	0.0
Buffalo.	+0.22	Min. 1806	+0.2
Erie.	—0.46	Max. 1808	—0.5
Pittsburgh.	—0.6	Max. 1808	—0.6
[Sault de Ste. Marie.	—0.5	Max. 1828	—1.2]

From the above table of epochs of extreme values we find, omitting the last station, the average time 1803 or 1804, so that the agonic line for 1800 occupies very nearly the extreme northern position reached on our Atlantic coast, the small change between the years 1800 and 1803½ being unimportant. The bend near Harrisburg may be local or general. A compromise position of this line is indicated on our plate No. 25.

The agonic line for 1850 has been taken from Coast Survey Report for 1856, Appendix No. 28, plate 61. The agonic line for 1875 has been taken from Coast Survey Report for 1876, Appendix No. 21, plate 24, with correction of the northern part taken from the U. S. Lake Survey, Professional Papers, Corps of Engineers, No. 24, plate XXX.

The prospective position for 1900 depends on the isogonic chart for the epoch 1885, brought forward by means of the annual change deduced from our investigations.*

The secular motion may be clearly apprehended from the several positions of the agonic line as given on the accompanying plate, No. 20, and as referred to in the preceding pages. We may remark that the change between 1600 or 1630 and 1700 should not be conceived as having been produced by a great sweep of the northern portion of the agonic curve across Europe and Africa, but rather as a gradual breaking through of the narrow neck of *east* declination in the vicinity of Cape Verde Islands, and thus readily uniting with the previously existing southern branch of the agonic line, which, in 1600, skirted the southwestern coast of Africa. The isolated patch of east declination thus produced apparently drifted off to the eastward and northward.†

Progressive change in the secular variation.—The progressive change noticed when examining at different times the position of the lines where the needle has arrived at elongation or at extreme range in the secular motion has already been referred to in a general way, and the systematic propagation of the phrase of *eastern* elongation across the United States, from the Atlantic to the Pacific, in about the lapse of a century, has been adverted to. Under the present heading it is proposed to enter somewhat more minutely into this remarkable phenomenon.

* Now (May, 1890) superseded by the issue in October, 1889, of a new isogonic chart for the epoch 1890.

† I find that the same idea was presented by E. Walker in his Adams Prize Essay on Magnetism for 1865; Cambridge, England, 1866.

The reader's attention may be directed to plate No. 43 of the new edition of Berghaus' Physikalischer Atlas, Gotha, 1888; it is a convenient plate of reference to the secular motion of the isogonic curves, though no new features relating to North America are there presented.

The following figures are taken directly from our table, column headed "Epoch of nearest *east* elongation," and beginning geographically in the extreme northeast we find the years of the last occurrence of this stationary phase of extreme elongation or of minimum west or its equivalent maximum east declination, as the case may be, at different localities as follows:

Halifax, N. S.	1714	Marietta and Cincinnati, Ohio.	1814
Eastport, Me.	1753	Florence, Ala.	1821
Bangor, Me.	1774	St. Louis, Mo.	1822
Portland, Me.	1779	Nashville, Tenn.	1834
Boston and Cambridge, Mass.	1780	Chicago, Ill.	1831
New Haven and Hartford, Conn.	1800	Denver, Colo.	1839
New York, N. Y.	1784	Salt Lake, Utah.	1873
Jamesburg, N. J.	1802	Vancouver, Wash. T.	1883
Philadelphia, Pa.	1802	Cape Mendocino, Cal.	1886
Pittsburgh, Pa.	1808	San Francisco, Cal.	1893 (Predicted.)

The opposite phase or that of the maximum west declination is now located between Charlottetown and Halifax, and may be expected in its supposed westward course to reach the latter place about 1894, Eastport, Me., about 1897, and Portland, Me., about 1917.

These places and corresponding times suffice to bring into strong relief the gradual progress within our geographical borders of what may aptly be called the crest (or hollow, as we may conceive) of the magnetic secular wave sweeping across the North American continent in about a century's time. Since this transfer of the eastern-elongation phase thus took place from east to west across the country, it is probable and may reasonably be inferred that with the present passing out into the Pacific of the eastern-elongation phase and the coming in of the opposite or western-elongation phase in the east, this intrusion of the latter phase, already commenced in northeastern Maine, will likewise spread itself in the course of time over and across the continent; in fact our formulæ do suppose this to take place. The question whether the secular motion of the eastern-elongation phase can be traced so far east as to reach Europe can not be definitely answered. We have for St. John's, Newfoundland, the date of 1704, and for Paris the year 1581, for the epoch of this phase, but unfortunately no intermediate stations by means of which to follow up the motion and assure us of its continuity; observations at the Azores, in southern Greenland, and in Iceland may possibly come to light to assist in this inquiry.

If we follow up the dates of the eastern magnetic elongation going south along our Atlantic coast, thence across the Gulf of Mexico and north along the Pacific coast, we notice the same law of gradual change as in our first table. A curve of *equal date* would fairly run parallel to our Atlantic coast line, and hold even as far south as Havana and Panama; similarly a curve of *equal date* on the Pacific coast from lower California up to the Straits of Fuca would not greatly deviate from it.

	Epoch of westerly minimum or easterly maximum.		Epoch of easterly maximum.
Charlottetown, Pr. Ed. Island.	1734	Vera Cruz, Mex.	1828
Eastport, Me.	1753	Acapulco, Mex.	1846
Nantucket, Mass.	1771	City of Mexico, Mex.	1848
Cape Henlopen, Del.	1802	San Blas, Mex.	1856
Charleston, S. C., and Savannah, Ga.	1804	Cape San Lucas, L. C.	1872
Havana, Cuba.	1797	San Diego, Cal.	1883
Kingston, Jamaica.	1778	Monterey, Cal.	1899*
Barbados.	1760	San Francisco, Cal.	1893*
		Cape Mendocino, Cal.	1886
		Cape Disappointment, Wash.	1905*
		Nee-ah Bay, Wash.	1887
		Nootka, Vancouver I.	1898*

* Predicted.

Beyond Vancouver Island and as we enter Alaska the dates again become earlier, as at Sitka, 1861, and in the whole region to the northward and westward, and including the chain of islands, the average date probably varies between 1830 and 1850 or thereabout. Near the eastern coast of Asia, west of Kamchatka, we encounter a complex system of isogonic curves, whose secular development, however, lies outside the limits of our research.

Looking over the numerical values of a, on which the length of the period depends, we notice a relation to geographical position, as also in the case of the epochal quantity c, of our general formula, the latter relation being less marked.

For stations on our Atlantic coast the values a are generally included between 1.30 and 1.50, implying periods of 277 and 240 years respectively, and the same limits will apply to the generality of places in the interior.

For stations south of the United States the value of a is decidedly less, as at Kingston, Barbados, Panama, Acapulco, City of Mexico, for which a varies between 1.0 and 1.1, with corresponding periods of 360 and 327 years. The value of a for Pacific coast stations, as San Diego, Santa Barbara, Monterey, San Francisco, and Cape Mendocino, remains low, averaging 1.10 (period 327 years); in Alaska it rises again to about 1.30 (period 277 years), with but little variation as far as it can be ascertained.

At first sight this diversity in the length of the period would seem to present a great obstacle in the way of explaining the cause of the secular variation through the action of an external or cosmical disturbing force which would be supposed to act alike at all stations. If we suppose the changes in the direction of the magnetic needle to be due to changes in the direction of electric currents or of electric impulses or waves traversing the earth's crust and permeating the same to a considerable depth, and altering by inductive action the magnetic condition of the earth itself, we may see in the diversity of the length of the period, and of the magnitude of deflection at different places, the effect of a systematic *swaying* and mutual disturbing action in the direction and intensity of such electric currents.

For the further development of the laws of secular variation in North America it would be of great importance to know what has been and is at present going on in the immediate vicinity of the magnetic pole (where the dip is 90° and the horizontal force zero) since Ross visited the region now more than half a century ago. We have no direct or observational evidence whatever whether the pole remains stationary or has shifted its position, and if the latter, how much and in what direction.

EARLY ATTEMPTS TO LOCATE THE NORTH AMERICAN MAGNETIC POLE.

On a map in the Mercator-Hondius Atlas, Amsterdam, 1630,* and which is projected with the geographical north pole in its center, and is supposed by Dr. Kohl to be due to Gerardus Mercator, the magnetic pole is placed in latitude 74° and on a line from the geographical pole to the Straits of Anian.† [Information extracted from "Bibliographical Contributions," No. 19, issued by Justin Winsor, Librarian Harvard University, Cambridge, 1886.]

A. v. Humboldt points out earlier attempts, which are also referred to by Mr. Winsor, viz: by Ruysch (about 1508), by Martin Cortez (about 1545), and by Liveo Sanuto (about 1588). The exact idea which was then attached to the term magnetic pole may remain a matter of conjecture, but we should remember that this was before the time the dip of the needle had been discovered,‡ or had become generally known, and long before any real notion of magnetic intensity could be formed.

On the map of the northwest coast, by C. de Judaeis, 1593, (copy No. 282 of the Kohl collection), the polus magnetis, on pinnacle rock, is placed in latitude 70° and in longitude of the mythical Anian regnum. [J. Winsor's B. C.] Although these early assignments of a definite location of the northern magnetic pole (where on the earth's surface the direction of the magnetic force and that of gravity coincide) are nothing more than fanciful conjectures, yet it is remarkable that these

* Copy No. 116 of the Kohl collection, State Department, Washington, D. C.

† The fictitious Strait of Anian of the 16th century was supposed to separate western North America from eastern Asia, and in particular from the island of Jesso, Japan.

‡ By George Hartmann (Dr. R. Wolf's Taschenbuch, Zurich, 1877), in the year 1544, but he could not measure the amount; R. Norman's independent rediscovery of 1576 was more fruitful.

guesses should not have been so very far from the mark. Halley, in 1683, assumed that there were two magnetic poles in the northern hemisphere of different intensity and of vertical dip (and similarly two poles in the opposite hemisphere), an idea, which under a different aspect, was further elaborated by Hansteen (1819), who even assigned long periods of rotation to his poles. It had then become known how to measure *relative* intensity, and a distinction was made between poles or foci of maximum total intensity and poles of vertical dip (or of vanishing horizontal component of magnetic force). It is to this last conception that the term pole is now more exclusively applied. The focal region of greatest total intensity to the southward and westward of Hudson Bay is a very extended one, whereas the pole of dip 90° is restricted to quite confined limits, depending on local irregularities of distribution.

Observations made in 1813 on board H. M. S. Brazen place the pole in latitude 69° and in longitude 92° west; in June, 1831, Sir James Clark Ross* reached, in latitude 70° 05′.3 and in longitude 96° 45′.8 west, a position on Boothia Felix where he observed a dip of 89° 59′, and this location, or one not far from it, has ever since been regarded as that of the North American pole. According to Gauss's general theory of terrestrial magnetism (1838), this pole was about the year 1830 in latitude 73° 35′ and in longitude 95° 39′ west of Greenwich. Whether or not the pole has shifted its place† can not at present be definitely decided, since Ross has as yet found no successor, though explorers in more recent times have visited the region for other purposes.

In conclusion a few remarks may be made respecting the accuracy of the observations, shown by the tabulated probable errors and derived from the differences of observed and computed values.

The probable errors of observation given in the tables will serve to convey some idea of the relative value of each series of observations. The imperfections in the instrumental means and methods of the older observations in many cases react unfavorably on the modern observations, which are generally made with more precise instruments and using more refined methods. If we take, for instance, the observations of Hudson, made in 1609, in the vicinity of New York, we find each fairly chargeable with a probable error of about ± 3 or 4°. While these observations are very imperfect, those of Champlain of about the same period (1604 to 1612) are no better. These two navigators differ nearly 9° off the mouth of the Penobscot, Maine, and nearly 12° off Cape Cod. The observations made by Vancouver on our western coast, between 1792 and 1794, are each subject to a probable uncertainty of at least ± 1°, and even in our own days it requires very favorable circumstances to determine the variation of the compass at sea with a probable error of, say, half a degree or less. At sea, increased precision was attained with the improvement of the azimuth compass and by allowance for disturbing effect of the ship's iron, and as regards shore stations, greater accuracy was obtained by the introduction of the theodolite for determining the astronomical meridian. With a portable magnetometer and a collimator magnet, the instrumental means need not introduce a greater uncertainty than about one minute; but the actual probable error of any determination is dependent also on the irregular variations in the direction of the magnetic force from day to day, thus making it desirable and indispensable for precise work to continue the observations for three or more days and to correct the individual results for diurnal variation. The amount of the probable error of an observed declination depends also on the intensity of the horizontal component of the magnetic force at the place, *i. e.*, in general the smaller the horizontal force the larger the apparent probable uncertainty.

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* Phil. Trans. Royal Society, 1833–'34.

† See, for instance, Grover's magnetic orbit (inclosing the geographical pole) in Sir W. Snow Harris's Rudimentary Magnetism, London, 1850—a speculation, however, not sufficiently supported by sound induction.

APPENDIX No. 8.—1888.

GEOGRAPHICAL POSITIONS OF TRIGONOMETRICAL POINTS IN THE STATE OF CONNECTICUT, DETERMINED BY THE U. S. COAST AND GEODETIC SURVEY BETWEEN THE YEARS 1833 AND 1886.

INTRODUCTION AND EXPLANATION OF THE TABULAR RESULTS.

By CHARLES A. SCHOTT, Assistant.

COMPUTING DIVISION, *March* 18, 1889.

The collection of geographical positions and of geodetic data resulting from the triangulations made in the State of Connecticut, herewith presented, is in continuation of the scheme of publishing the results of the Survey in those States where the field-work is substantially completed with respect to the immediate objects of the Survey and where the triangulation could be made to rest on the standard geodetic data of the Survey. These data are—

The unit of length.—The metre, and in particular the French Committee metre brought to this country in 1805 by F. R. Hassler, afterwards first Superintendent of the Coast Survey. It is the property of the American Philosophical Society, Philadelphia. The length of this standard will be compared with that of the *new* international standard as soon as its representative bar is received here. The difference in length between these metres is already known to be very small and only needs consideration when high scientific accuracy is involved (see App. 7, Rep. for 1867).*

The geodetic surface of reference.—The spheroid of rotation, most nearly conforming to the earth's figure and size, as deduced in 1866 by Captain A. R. Clarke, R. E., and which superseded in February, 1880, the Besselian spheroid, which had up to that time been used on the Survey. Its dimensions are:

Equatorial semi-diameter	$6\ 378\ 206.4^{m}$
Polar semi-axis	$6\ 356\ 583.8^{m}$
Ratio $a:b=294.98:293.98$	

The standard latitude.—Is that of the primary triangulation on the Atlantic coast, viz: Principio station $\varphi = 39^{\circ}\ 35'\ 36''.692$ (see App. 8, Rep. for 1879).

The standard longitude.—Is that resulting from the telegraphic longitude system, connecting directly with Greenwich as the initial point; we have for Principio station $\lambda = 76^{\circ}\ 00'\ 16''.407$ west from Greenwich (see App. 11, Rep. for 1884).

The standard azimuth.—Is that of the primary triangulation, viz: Principio to Turkey station $\alpha_0 = 1^{\circ}\ 34'\ 36''.413$ (see App. 8, Rep. for 1879).

The preliminary results published in Appendix 12, Report for 1851, Appendix 15, Report for 1864, and Appendix 13, Report for 1868, are now superseded by reason of change of geodetic and astronomical data and for want of adjustment.

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* Page 134, for 1802 read 1805.

Respecting elevations of stations above the average sea-level, the Survey is not at present in a condition to furnish them.

Descriptions of stations, how marked on surface and below ground, can generally be given on application to the Office.

The positions and connecting lines of all adjusted stations are shown on the accompanying map; all less important points are indicated by dots. The scale of the map $\frac{1}{300000}$ is the same as that of the two sketches in Appendix 8, Report for 1885, of the triangulations of Massachusetts and Rhode Island.

The method of treatment of the reduction of the observations is the same as that adopted for the States just named. The main triangulation, entering Connecticut in the southwest, crosses the State, but the subordinate triangulation of Long Island Sound is the principal support of the coast work. The adjustment of the secondary triangulation of Long Island Sound is shown in Appendix 8, Report for 1868, and the distances and angles there given are retained unaltered.

In a general way and sufficient for illustration we may explain the process of computing and of producing systematic results as follows: The position of that particular trigonometrical station which is connected *most strongly* with the main triangulation is first fixed by adjustment, taking into consideration the lines directed to it from primary stations as well as lines diverging from it and intersecting the latter. Should there be more than one such point, say two or more, having equal strength of connection, they may be treated together in one least-square adjustment. In this manner point after point or a series of such is adjusted in position, so that the sum of the squares of the corrections to the observed horizontal directions shall be a minimum; the geometrical relations of the *preceding* points being always considered as fixed with respect to the variable elements of the new point or points under treatment. The principal secondary stations having thus become known in position, the tertiary positions are determined in the same systematic though somewhat less elaborate manner than that followed for the secondaries, and generally without leas square adjustment.

The final result of this systematic treatment may be summarized by stating that no discrepancy remains in the results themselves, and that the length and direction of any side of a triangle may be computed from any starting side, and through any series of connecting triangles, and yet the same results will be reached.

The latitudes and longitudes of the trigonometrical points were computed by the usual formulæ, aided by the tables ordinarily employed in the Survey, for which see Appendix No. 7, Report for 1884. For primary sides, not exceeding in length (s) 100 or 150 kilometres (about 62 or 93 statute miles), the formulæ for difference of latitude ($\Delta\varphi$), difference of longitude ($\Delta\lambda$), and difference of azimuth ($\Delta\alpha$), are very accurate or sufficiently perfect for the purpose; these are:*

$$
\begin{aligned}
-\Delta\varphi &= s.\cos\alpha\,.\,\mathrm{B} + s^2.\sin^2\alpha\,.\,\mathrm{C} + (\Delta\varphi)^2\,\mathrm{D} - \Delta\varphi\,.\,s^2.\sin^2\alpha\,.\,\mathrm{E} \\
\Delta\lambda &= s\,.\sin\alpha\,.\sec.\varphi'\,.\,\mathrm{A}' \\
-\Delta\alpha &= \Delta\lambda\,.\sin\tfrac{1}{2}(\varphi+\varphi')\sec.\tfrac{1}{2}(\Delta\varphi) + (\Delta\lambda)^3.\,\mathrm{F}
\end{aligned}
$$

hence the results for the new position

$$
\begin{aligned}
\varphi' &= \varphi + \Delta\varphi \\
\lambda' &= \lambda + \Delta\lambda \\
\alpha' &= \alpha + \Delta\alpha + 180^\circ
\end{aligned}
$$

For sides not exceeeding 25 or 30 kilometres (about 15 or 19 statute miles) the fourth term in the expression for $\Delta\varphi$ may be omitted, also the factor sec. $\frac{1}{2}(\Delta\varphi)$, as well as the second term in the expression for $\Delta\alpha$. For full explanation, forms, examples, and auxiliary tables the reader may consult the appendix cited above.

There also is shown the inverse problem, viz, given φ and λ and φ' and λ' (or φ φ' and $\Delta\lambda$) to find s and α and α'. This process may be used in cases where the required distance and azimuths are not directly contained in the table of results.

*With slightly changed notation conformably to more modern practice.

For the direct solution put:

$$\begin{cases} s\,.\cos.\,\alpha = x = -\dfrac{1}{\mathrm{B}}\left(\varDelta\varphi + \mathrm{C}\,.\,y^2 + \mathrm{D}\,.\,(\varDelta\varphi)^2 + \mathrm{E}\,.\,(\varDelta\varphi)\,y^2 + \mathrm{E}\,.\,\mathrm{C}\,.\,y^4\right) \\ s\,.\,\sin\,\alpha = y = \dfrac{\varDelta\lambda\,\cos\,\varphi'}{\mathrm{A}'} \end{cases}$$

whence

$$\tan\alpha = \frac{y}{x} \quad \text{and} \quad s = x\sec.\,\alpha = y\,\mathrm{cosec}.\,\alpha$$

In secondary and tertiary work the terms in E may be omitted.

For convenience of computing secondary and tertiary positions, the logarithms of factors A, B, C, D, E, are here reproduced for the limiting latitudes 40° 55′ to 42° 55′ so as to cover the parallels of Connecticut, Rhode Island, and Massachusetts, and two applications are added, one to exemplify the direct, the other the inverse process. In the first case we start from a known point ($\varphi\ \lambda$) and determine the position ($\varphi'\ \lambda'$) of a second point, the distance (s) and direction (α) of which from the given point are known from triangulation; in the second case we have given the position of two points ($\varphi\ \lambda$ and $\varphi'\ \lambda'$) and require the distance (s) between them and their directions ($\alpha\ \alpha'$). For further explanation Appendix No. 7, Report for 1884, should be consulted.

Table of log. factors for the computation of geodetic positions, between latitudes 40° 55′ and 42° 55′.

φ	log. A diff. for 1″, −0.07	log. B diff. for 1″, −0.21	log. C diff. for 1″, +0.42	log. D	log. E
° ′					
40 55	8.509 0952	8.510 7819	1.34231	2.3886	6.1236
56	947	806	256		
57	943	793	282		
58	939	781	307		
59	934	768	332		
41 00	8.509 0930	8.510 7755	1.34358	2.3888	6.1253
01	926	742	383		
02	922	730	408		
03	918	717	434		
04	913	704	459		
41 05	8.509 0909	8.510 7691	1.34484	2.3890	6.1271
06	905	679	510		
07	900	666	535		
08	896	653	560		
09	892	640	586		
41 10	8.509 0888	8.510 7628	1.34611	2.3891	6.1289
11	883	615	636		
12	879	602	662		
13	875	590	687		
14	871	577	712		
41 15	8.509 0867	8.510 7564	1.34738	2.3893	6.1306
16	862	551	763		
17	858	539	788		
18	854	526	814		
19	849	513	839		

Table of log. factors for the computation of geodetic positions, etc.—continued.

φ	log. A diff. for 1″, —0.07	log. B diff. for 1″, —0.21	log. C diff. for 1″, +0.42	log. D	log. E
° ′					
41 20	8.509 0845	8.510 7500	1.34864	2.3895	6.1324
21	841	488	890		
22	837	475	915		
23	832	462	940		
24	828	449	965		
41 25	8.509 0824	8.510 7436	1.34991	2.3897	6.1342
26	820	424	1.35016		
27	815	411	041		
28	811	398	066		
29	807	385	092		
41 30	8.509 0803	8.510 7373	1.35117	2.3898	6.1360
31	798	360	142		
32	794	347	168		
33	790	334	193		
34	786	322	218		
41 35	8.509 0781	8.510 7309	1.35243	2.3900	6.1378
36	777	296	269		
37	773	283	294		
38	769	270	319		
39	764	258	345		
41 40	8.509 0760	8.510 7245	1.35370	2.3901	6.1395
41	756	232	395		
42	752	219	420		
43	747	207	446		
44	743	194	471		
41 45	8.509 0739	8.510 7181	1.35496	2.3903	6.1413
46	735	168	522		
47	730	155	547		
48	726	143	572		
49	722	130	597		
41 50	8.509 0718	8.510 7117	1.35623	2.3904	6.1431
51	713	104	648		
52	709	091	673		
53	705	079	698		
54	700	066	723		
41 55	8.509 0696	8.510 7053	1.35749	2.3906	6.1449
56	692	040	774		
57	688	027	799		
58	683	015	824		
59	679	002	850		
42 00	8.509 0675	8.510 6989	1.35875	2.3907	6.1467
01	671	976	900		
02	666	964	925		
03	662	951	951		
04	658	938	976		

Table of log. factors for the computation of geodetic positions, etc.—continued.

φ	log. A diff. for 1″, —0.07	log. B diff. for 1″, —0.21	log. C diff. for 1″, +0.42	log. D	log. E
° ′					
42 05	8.509 0654	8.510 6925	1.36001	2.3909	6.1485
06	649	912	026		
07	645	900	052		
08	641	887	077		
09	636	874	102		
42 10	8.509 0632	8.510 6861	1.36127	2.3910	6.1503
11	628	848	152		
12	624	836	178		
13	619	823	203		
14	615	810	228		
42 15	8.509 0611	8.510 6797	1.36253	2.3911	6.1521
16	607	784	278		
17	602	772	304		
18	598	759	329		
19	594	746	354		
42 20	8.509 0590	8.510 6733	1.36379	2.3913	6.1539
21	585	720	404		
22	581	707	430		
23	577	695	455		
24	572	682	480		
42 25	8.509 0568	8.510 6669	1.36505	2.3914	6.1557
26	564	656	530		
27	560	643	556		
28	555	631	581		
29	551	618	606		
42 30	8.509 0547	8.510 6605	1.36631	2.3915	6.1575
31	543	592	656		
32	538	579	682		
33	534	566	707		
34	530	554	732		
42 35	8.510 0525	8.510 6541	1.36757	2.3916	6.1593
36	521	528	782		
37	517	515	808		
38	513	502	833		
39	508	490	858		
42 40	8.509 0504	8.510 6477	1.36883	2.3917	6.1612
41	500	464	908		
42	496	451	934		
43	491	438	959		
44	487	425	984		
42 45	8.509 0483	8.510 6413	1.37009	2.3918	6.1630
46	478	400	034		
47	474	387	059		
48	470	374	085		
49	466	361	110		

Table of log. factors for the computation of geodetic positions, etc.—continued.

φ	log. A diff. for 1″, —0.07	log. B diff. for 1″, —0.21	log. C diff. for 1″, +0.42	log. D	log. E
° ′					
42 50	8. 509 0461	8. 510 6348	1. 37135	2. 3919	6. 1648
51	457	336	160		
52	453	323	185		
53	448	310	210		
54	444	297	235		
42 55	8. 509 0440	8. 510 6284	1. 37261	2. 3920	6. 1666

Position computation. Form for direct computation.

		°	′	″
α	School-house Hill to Box Hill.	230	00	56. 6
$\angle$	Talcott and Box Hill..	— 79	58	58. 4
α	School-house Hill to Talcott.	150	01	58. 2
$\Delta\alpha$		—	4	42. 4
α'	Talcott to School-house Hill.	329	57	15. 8

	°	′	″			°	′	″
φ	41	39	31. 321	School-house Hill.	λ	72	40	52. 913
$\Delta\varphi$	+	9	10. 316	*Metres.* 19606. 04	$\Delta\lambda$	+	7	04. 273
φ'	41	48	41. 637	Talcott.	λ'	72	47	57. 186

$\frac{1}{2}(\varphi+\varphi')$ = 41° 44′ 06″		s	4. 2923898	s^2	8. 5848		
		Cos α	$_n$9. 9376742	Sin² α	9. 3971	$(\Delta\varphi)^2$	5. 48
	″	B	8. 5107251	C	1. 3536	D	2. 39
1st term.	—550. 540		$_n$2. 7407891		9. 3355		7. 87
2d & 3d terms.	+ 0. 224				+0. 217		+0. 007
— $\Delta\varphi$	—550. 316						

s	4. 2923898		
Sin α	9. 6985387		
A′	8. 5090723	$\Delta\lambda$	2. 62765
Cos φ' ar. co.	0. 1276447	Sin $\frac{1}{2}(\varphi+\varphi')$	9. 82327
	2. 6276455		2. 45092
	″		″
$\Delta\lambda$	+424. 273	— $\Delta\alpha$	+282. 4

Position computation. Form for inverse solution.

		°	′	″
α				
$\angle$				
α	Stamford Harbor L. H. to Round Hill 2.	132	15	36.2
$\Delta\alpha$		—	5	09.7
α'	Round Hill 2 to Stamford Harbor L. H.	312	10	26.5

	°	′	″			°	′	″
φ	41	00	49.212	Stamford Har. L. H.	λ	73	32	34.740
$\Delta\varphi$	+	5	23.810	*Metres.* 14865.77	$\Delta\lambda$	+	7	51.490
φ'	41	06	13.022	Round Hill 2.	λ'	73	40	26.230

$\frac{1}{2}(\varphi+\varphi')=41°\ 03'\ 31''$		s	3.9998778	s^2	8.0830	$(\Delta\varphi)^2$	5.02
		Cos α		Sin^2 α			
		B	8.5107744	C	1.3438	D	2.39
	″						
1st term.	—324.080		$_n$2.5106522		9.4268		7.41
2d & 3d terms.	+ 0.270				+0.267		+0.003
— $\Delta\varphi$	—323.810						

s Sin α	4.0414780			s. sin α	4.0414780
				s. cos α	$_n$3.9998778
A′	8.5090904	$\Delta\lambda$	2.67347	tan α	$_n$0.0416002
Cos φ' ar. co.	0.1229041	Sin $\frac{1}{2}(\varphi+\varphi')$	9.81745	α	132° 15′ 36″.2
	2.6734725		2.49092	Sin α	9.8692905
	″		″	s	4.1721875
$\Delta\lambda$	+471.490	— $\Delta\alpha$	+309.7		

We have also the length of the angular measures of one minute in the meridian and in the parallel φ, given by the formulæ

$$1' \text{ of the meridian} = 1852^{m}.2015 - 9^{m}.4342 \cos 2\varphi + \overset{m}{0}.020 \cos . 4\varphi - \ldots$$

$$1' \text{ of the parallel} = 1856^{m}.9183 \cos . \varphi - 1^{m}.5757 \cos . 3\varphi + \overset{m}{0}.002 \cos 5\varphi - \ldots$$

whence the following tabular values expressed in metres:

Latitude.	Arc of 1′	
	In meridian.	In parallel.
° ′	*m*	*m*
40 00	1850. 54	1423. 27
20	0. 65	16. 33
40	0. 76	09. 34
41 00	0. 87	1402. 29
20	0. 98	95. 20
40	1. 09	88. 07
42 00	1. 19	1380. 89
20	1. 30	73. 66
40	1. 41	66. 38
43 00	1851. 52	1359. 05

The effect of the earth's curvature may be estimated from the fact that the area of a triangle in latitude 40° having one second (1″) of spherical excess, is 76.060 square statute miles; in latitude 41°, 76.078 square statute miles, and in latitude 42°, 76.096 square statute miles. The shape of the triangle is of no consequence. To convert square statute miles into square kilometres we have the relations, 1 sq. st. mile = 2.589998 sq. km., and 1 sq. km. = 0.386101 sq. st. miles.

For convenience of reference the positions are arranged in geographical groups after giving the primary, the subordinate primary and the secondary stations over the whole State. These subdivisions are as follows:

	Number of stations.
1. Primary stations.	15
2. Subordinate primary and secondary stations.	18
3. Rhode Island State line to Thames River.	39
4. Thames River.	70
5. Thames River to Connecticut River.	27
6. Connecticut River.	145
7. Connecticut River to Housatonic River.	247
8. Housatonic River to New York State line.	256
Total number.	817

Of these 817 points there are 58 outside the boundaries of the State, but repeated here for the purpose of showing the connection of the triangulation with those of the adjacent States—Massachusetts, Rhode Island, and New York. Necessarily some of these 58 points have already appeared in Appendix No. 8, Report for 1885.

We have the following statistics respecting observers and years of observation:

Name of observer.	Years of observation.	Name of observer.	Years of observation.
A. D. Bache.	1861, 1862	F. H. Gerdes.	1840
R. M. Bache.	1873, 1874, 1875, 1876, 1877	E. Goodfellow.	1871
E. Blunt.	1836, 1837, 1838, 1840, 1853, 1861, 1863, 1865	R. E. Halter.	1861, 1862, 1863, 1864, 1875
G. Bradford.	1881, 1882, 1883, 1884, 1885	F. R. Hassler.	1833
J. G. Bramley, F. C.*	1882	W. C. Hodgkins.	1883, 1884, 1886
J. P. Bogart, F. C.*	1882	C. Hosmer.	1869
H. Caperton, jr.	1875	S. C. McCorkle.	1882, 1883
G. W. Dean.	1861, 1862, 1863, 1864	A. T. Mosman.	1864, 1865
F. H. Dietz.	1861, 1862	H. G. Ogden.	1874
C. M. Eakin.	1839	D. C. Sanford, F. C.*	1882
W. S. Edwards.	1861, 1862	W. H. Stearns.	1873
J. Ferguson.	1833, 1834	J. A. Sullivan.	1863, 1864, 1865, 1882
H. R. Garland.	1881, 1882	W. H. Swift.	1835
		J. B. Tolley.	1886
		C. H. Van Orden.	1886

* In connection with the State Shell-Fishery Commission.

The whole number of triangles formed and computed was 2251; the number of occupied trigonometrical stations within the State is 325. A number of computers was engaged on this work, but the principal share of it fell to Mr. E. H. Courtenay, of the Computing Division, who supervised their work. The accuracy of the results is chiefly due to Mr. Courtenay, who spared no labor to render them as perfect as possible. These computations were made principally between the years 1883 and 1888.

While the primaries, subordinate primaries, and principal secondaries possess all desirable accuracy, the minor secondaries and principally the earlier tertiaries, now over half a century old, are of somewhat inferior accuracy as compared with the same class of work in adjoining States. Modern work, however, greatly contributed to confine the effect of any inferior part to narrow limits, and its accuracy may be estimated as twice that of the very oldest.

Respecting the accuracy of a triangulation, the mean error m of an adjusted or resulting angle has been advantageously employed as a quantity of comparison for different triangulations by which to judge of their relative value (see *e. g.*, Coast and Geodetic Survey Report for 1884, p. 389). The value m may be deduced in various more or less accurate ways, according to circumstances; in adjusted triangulations it may readily be deduced from

$$m=1.25\sqrt{\frac{2}{n.s.}}\cdot\Sigma\,[c]$$

Where $\Sigma\,[c]$ is the sum of corrections to observed *directions*, n the number of conditional equations involved, and s the number of directions in the adjusted figure; or, in unadjusted work, it may be found from

$$m=\sqrt{\frac{\Sigma e^2}{3t}}$$

or, without squaring, from

$$m=1.25\frac{[e}{t\sqrt{3}}$$

where e=triangle closing error (or difference from $\pi+\varepsilon$), to be taken numerically without regard to sign in last formula, and t=number of triangles. We thus find for the adjusted triangulation in the State the average value $m = \pm 5''.9$, likewise for the unadjusted triangulation $m = \pm 4''.8$; the deviations, however, from this latter value are very great, rising and falling between, say, 4″ and 8″, according to circumstances. The accuracy of the triangulation may otherwise be roughly expressed in terms of the distance, and thus estimated, the average error of secondary work may be taken to range between $\frac{1}{40000}$ and $\frac{1}{20000}$ of the length, whereas that of tertiary work barely comes up to $\frac{1}{10000}$, and in parts may be as low as $\frac{1}{5000}$ of the length.

There remain but a few words to be added explanatory of the table of results. Column 1 contains the names of the stations, column 2 the latitude, column 4 the longitude, columns 3 and 5 contain the equivalents in metres of the seconds (in arc) of latitude and longitude respectively, solely for the use of the draughtsman in projections; column 6 gives the azimuth of the first to the second named station, counted from south round by west from 0° to 360°; it is followed by the reversed azimuth in the next column. The distances are all referred to the surface of the spheroid at the average sea-level. Those who may prefer the English foot as the unit of length can readily make the conversion from one unit into the other by means of the following tables:*

1 m. =	3. 28083 ft.	1 ft. =	0. 304801 m.
2	6. 56167	2	0. 609602
3	9. 84250	3	0. 914402
4	13. 12333	4	1. 219202
5	16. 40417	5	1. 524003
6	19. 68500	6	1. 828804
7	22. 96583	7	2. 133604
8	26. 24667	8	2. 438405
9	29. 52750	9	2. 743205
10	32. 80833	10	3. 048006

and for the conversion of kilometres into statute miles, and *vice versa*:

1 km. =	0. 621370 st. m.	1 st. m. =	1. 609347 km.
2	1. 242740	2	3. 218694
3	1. 864110	3	4. 828042
4	2. 485480	4	6. 437388
5	3. 106850	5	8. 046736
6	3. 728219	6	9. 656083
7	4. 349589	7	11. 265430
8	4. 970959	8	12. 874778
9	5. 592329	9	14. 484125
10	6. 213699	10	16. 093472

P. S.—The following errata refer to Appendix No. 8, Report for 1885, containing the geodetic positions in Massachusetts and Rhode Island:

Page 288, line 17, for 125 read 1.25.
Page 294, line 13, for 370 read 372.
Page 304, line 13, omit "and latitude."
Page 308, line 8 from bottom, for 57.08 read 57.10, and for 1761.3 read 1761.8.
Page 310, line 5, for 231.8 read 27.5.
Page 340, line 4, add 1861.
Page 340, line 5, add 1861.
Page 358, line 9 from bottom, for 833.0 read 883.0.
Page 366, line 3 from bottom, for 1243.2 read 1551.7.
Page 409, line 3 from bottom, after Pawkhungernock ch. add (Ct.).
Page 415, line 2 from bottom, for Simmons read Simmons 2.
Page 424, line 15, for 1709.5 read 1609.5.
Page 425, line 18, for 3404.1 read 3104.1.
Page 434, line 10, after Pawkhungernock ch. add (Ct.).

* U. S. Coast and Geodetic Survey. Office of Standard Weights and Measures. T. C. Mendenhall, Superintendent. Tables for converting Customary and Metric Weights and Measures. Washington, D. C., January 1890.

Index of stations in Connecticut.

* Or Mount Washington or Mount Everett or Taughanuc Mount or Dome Peak.

Index of stations in Connecticut—continued.

Index of stations in Connecticut—continued.

Index of stations in Connecticut—continued.

Index of stations in Connecticut—continued.

Index of stations in Connecticut—continued.

Index of stations in Connecticut—continued.

Index of stations in Connecticut—continued.

Index of stations in Connecticut—continued.

PRIMARY STATIONS.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Wachusett, astronomical azimuth station of 1860, Mass.	42 29 20.784	641.4	71 53 13.984	319.4
Mount Tom, astronomical azimuth station of 1862, Mass.	42 14 30.798	950.2	72 38 55.056	1262.3
Bald Hill (Tolland County).	41 58 25.890	798.9	72 11 55.027	1266.9
Box Hill.	41 47 59.794	1844.9	72 27 21.404	494.1
Sandford, astronomical azimuth station of 1862.	41 27 42.801	1320.4	72 56 59.304	1376.3
Sandford, astronomical latitude station of 1862.	41 27 43.193	1332.5	72 56 59.847	1389.0
Ivy.	41 52 18.500	570.7	73 13 27.926	644.0
Wooster.	41 21 03.978	122.7	73 29 18.136	421.6
West Hills, astronomical azimuth station of 1865, N. Y.	40 48 55.188	1702.4	73 25 32.405	759.5
Tashua.	41 15 37.844	1167.4	73 15 01.332	31.0
Ruland, N. Y.	40 50 41.755	1288.0	73 01 58.332	1366.5
Bald Hill (Fairfield County).	41 12 49.857	1538.0	73 28 41.682	971.0
Round Hill.	41 06 13.173	406.4	73 40 25.788	601.8
Harrow, N. Y.	40 47 55.506	1712.2	73 38 22.231	521.2
Buttermilk, N. Y.	41 06 36.437	1124.0	73 48 38.898	907.5

SUBORDINATE PRIMARY AND SECONDARY STATIONS.

Friar's Head, N. Y.	40 58 15.895	490.2	72 43 41.404	968.1
Sugarloaf.	41 22 31.857	982.8	72 43 54.970	1277.3
Shelter Island, N. Y.	41 04 38.995	1202.9	72 21 39.788	928.8
Williams.	41 21 18.946	584.5	72 31 09.574	222.6
Nickerson.	41 23 53.849	1661.3	72 19 39.558	918.9
Montauk, N. Y.	41 03 54.392	1677.9	71 54 18.426	430.2
Mount Prospect, N. Y.	41 15 21.508	663.5	72 00 35.924	836.3

PRIMARY STATIONS.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
246 05 57.988	66 36 45.098	Wachusett	68470.37	4.8355027
204 05 01.004	24 17 34.496	Wachusett	62740.03	4.7975447
128 48 17.330	308 30 11.049	Mount Tom.	47662.88	4.6781803
162 03 16.319	341 55 31.984	Mount Tom	51616.87	4.7127917
227 47 14.069	47 57 32.578	Bald Hill (Tolland County).	28797.56	4.4593557
196 00 11.934	16 12 15.370	Mount Tom	90171.62	4.9550699
227 27 39.231	47 47 20.351	Box Hill.	55707.02	4.7459099
333 14 07.820	153 25 05.059	Sandford	50949.29	4.7071382
276 52 14.769	97 23 00.053	Box Hill.	64330.97	4.8084201
254 32 28.198	74 53 50.541	Sandford	46684.33	4.6691711
200 44 28.824	20 54 59.842	Ivy.	61874.79	4.7915137
208 56 12.090	29 14 59.131	Sandford	82170.51	4.9147160
174 57 35.759	354 55 07.417	Wooster.	59732.68	4.7762120
16 39 36.292	196 32 41.953	West Hills	51589.49	4.7125612
116 51 42.509	296 42 16.951	Wooster.	22327.29	4.3488360
84 27 45.206	264 12 20.657	West Hills	33296.37	4.5223969
158 27 28.060	338 18 53.818	Tashua.	49641.82	4.6958477
354 16 33.290	174 18 37.504	West Hills	44476.98	4.6481353
254 44 52.060	74 53 52.816	Tashua.	19794.32	4.2965406
233 14 02.530	53 21 45.936	Bald Hill (Fairfield County)	20475.57	4.3112359
326 47 39.585	146 57 25.222	West Hills.	38232.60	4.5824338
264 06 16.919	84 14 40.010	West Hills	18138.02	4.2585898
175 07 59.132	355 06 38.150	Round Hill.	33983.42	4.5312670
273 31 26.560	93 36 50.763	Round Hill	11528.45	4.0617709
337 18 10.673	157 24 54.875	Harrow.	37465.19	4.5736279

SUBORDINATE PRIMARY AND SECONDARY STATIONS.

126 24 25.94	306 03 49.73	Tashua	54376.49	4.7354112
61 28 45.63	241 16 47.31	Ruland.	29245.95	4.4660658
73 46 33.99	253 26 01.75	Tashua	45249.26	4.6556115
359 35 43.43	179 35 52.36	Friar's Head.	44915.73	4.6523985
136 54 19.20	316 39 39.26	Sugarloaf	45414.57	4.6571952
69 10 35.87	248 56 08.39	Friar's Head.	33061.14	4.5193178
97 16 35.42	277 08 09.60	Sugarloaf	17930.94	4.2536030
336 39 59.31	156 46 14.75	Shelter Island.	33581.87	4.5261049
73 28 04.33	253 20 28.22	Williams	16731.50	4.2235348
4 30 16.58	184 28 57.33	Shelter Island.	35736.07	4.5531068
136 23 07.61	316 06 25.04	Nickerson	51226.72	4.7094965
92 12 22.36	271 54 23.99	Shelter Island.	38344.41	4.5837020
120 49 37.76	300 37 02.55	Nickerson	30937.89	4.4904907
337 24 58.80	157 29 07.26	Montauk.	22951.28	4.3608068

SUBORDINATE PRIMARY AND SECONDARY STATIONS—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Lantern Hill.	41 27 37.929	1170.1	71 56 40.826	947.5
Block Island, R. I.	41 10 32.077	989.5	71 35 30.644	714.3
Watch Hill, R. I.	41 18 49.932	1540.4	71 51 17.201	400.1
Champlin, R. I.	41 29 16.000	493.6	71 46 47.766	1108.2
Mount Tom.	41 41 36.426	1123.7	73 16 25.536	590.5
Good.	41 32 55.526	1713.0	73 15 36.757	851.9
Clove, N. Y.	41 41 18.559	572.6	73 41 36.056	833.8
Osborne, N. Y.	41 35 16.901	521.4	73 32 29.317	679.0
Plymouth, N. Y.	41 46 25.408	783.9	73 37 17.277	399.0
Bald Peak (or Mount Washington or Dome Peak or Mount Everett or Taughanuc Mountain), Mass.	42 06 07.301	225.3	73 25 59.109	1358.2
Dickerson, N. Y.	41 15 32.132	991.3	73 52 02.378	55.4

RHODE ISLAND STATE LINE TO THAMES RIVER.

Wilcox, R. I.	41 21 23.198	715.5	71 43 59.859	1391.4
Peleg Tiff, R. I.	41 23 18.746	578.4	71 48 40.418	939.0
Eel's Hill 2. 1838.	41 22 49.868	1538.4	71 51 04.352	101.1
Quacatog.	41 23 15.294	471.8	71 56 58.572	1360.9
Fort Hill.	41.20 47.702	1471.6	72 00 40.707	946.4
Chocomount, N. Y.	41 16 48.064	1482.8	71 57 48.053	1118.3
Wampasset.	41 19 44.648	1377.4	71 55 16.929	393.6
Avery's Point.	41 18 57.590	1776.7	72 03 52.585	1223.0
Groton Long Point.	41 18 26.804	827.0	72 00 21.290	495.2
Morgan's Point (Mystic) L. H. 1835.	41 18 59.410	1832.8	71 59 23.215	539.9

SUBORDINATE PRIMARY AND SECONDARY STATIONS—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
77 56 29.24	257 41 16.94	Nickerson	32750.90	4.5152233
355 40 13.08	175 41 46.99	Montauk.	44039.99	4.6438472
137 05 08.88	316 51 10.25	Lantern Hill	43293.35	4.6364212
65 06 14.69	244 53 53.01	Montauk.	29029.62	4.4628414
304 46 59.34	124 57 23.38	Block Island	26863.71	4.4291660
155 15 02.20	335 11 28.24	Lantern Hill.	17940.44	4.2538331
77 39 16.69	257 32 43.91	Lantern Hill	14089.65	4.1489001
335 30 49.75	155 38 16.93	Block Island.	38080.36	4.5807010
357 39 55.72	177 40 51.49	Tashua	48122.57	4.6823488
25 17 53.27	205 09 21.10	Wooster.	42030.37	4.6235632
358 31 27.66	178 31 51.09	Tashua	32023.07	4.5054630
41 03 04.58	220 54 00.85	Wooster.	29075.19	4.4635225
335 23 21.45	155 31 30.60	Wooster	41192.23	4.6148153
268 57 23.15	89 14 07.82	Mount Tom.	34936.21	4.5432758
219 49 21.75	40 02 01.49	Ivy	41100.75	4.6138498
280 26 17.73	100 37 29.58	Good.	23862.57	4.3777172
251 35 32.61	71 51 25.74	Ivy	34739.43	4.5408227
342 04 35.06	162 07 46.55	Osborne.	21673.21	4.3359233
343 42 11.27	163 48 34.31	Mount Tom	47267.34	4.6745611
25 16 18.35	205 05 52.68	Clove.	50756.55	4.7054921
251 59 49.34	72 14 49.83	Wooster	33347.17	4.5230590
278 35 48.49	98 51 11.78	Bald Hill (Fairfield County).	33001.03	4.5185275

RHODE ISLAND STATE LINE TO THAMES RIVER.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
329 24 30.3	149 30 06.2	Block Island	23323.0	4.367785
165 02 57.7	345 01 06.6	Champlin.	15098.2	4.178925
193 20 20.5	13 21 35.1	Champlin	11327.4	4.054131
125 40 31.8	305 35 14.0	Lantern Hill.	13725.1	4.137517
138 42 24.9	318 38 42.3	Lantern Hill	11833.3	4.073108
206 32 46.3	26 35 36.1	Champlin.	13318.8	4.124466
19 05 53.7	199 03 30.2	Mount Prospect	15465.5	4.189365
182 54 36.2	2 54 48.0	Lantern Hill.	8112.8	3.909172
359 21 58.4	179 22 01.6	Mount Prospect	10063.5	4.002749
285 26 40.2	105 32 52.3	Watch Hill.	13598.4	4.133488
55 40 07.5	235 38 16.8	Mount Prospect	4732.7	3.675106
151 30 12.3	331 28 18.3	Fort Hill.	8413.1	3.924956
32 51 04.1	212 49 24.4	Chocomount	6483.5	3.811808
104 31 01.3	284 27 27.5	Fort Hill.	7775.6	3.890736
295 11 36.4	115 15 37.0	Chocomount	9375.3	3.971986
232 42 00.2	52 44 06.9	Fort Hill.	5607.9	3.748798
3 24 39.5	183 24 29.8	Mount Prospect	5726.4	3.757879
100 57 21.5	280 55 02.0	Avery's Point.	5005.9	3.699478
53 20 00.4	233 19 22.1	Groton Long Point	1684.2	3.226406
331 20 19.6	151 21 22.4	Chocomount.	4617.4	3.664396

RHODE ISLAND STATE LINE TO THAMES RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Stonington Harbor L. H. 1835.	41 19 39.033	1204.1	71 54 20.950	487.2
Pawkhungernock Church. 1838.	41 30 20.058	618.8	71 50 25.464	590.6
Mount Prospect 2, N. Y. 1874.	41 15 21.542	664.6	72 00 35.872	835.1
Fort Hill 2. 1882.	41 20 47.821	1475.3	72 00 40.650	945.1
Groton Long Point 2. 1882.	41 18 25.090	774.0	72 00 19.932	463.7
Stonington Harbor L. H. 1873–'86.	41 19 42.719	1317.9	71 54 21.588	502.1
Frost.	41 20 57.572	1776.1	71 51 03.250	75.6
Morgan's Point (Mystic) L. H. 1874–'86.	41 18 59.428	1833.3	71 59 23.672	550.6
Road Meeting-house. 1838.	41 22 23.44	723.1	71 54 51.18	1189.4
Grant's Hill.	41 25 25.17	776.5	71 54 06.05	140.5
Jesse Main.	41 26 31.63	975.8	71 49 15.00	348.3
Chapman's Hill.	41 29 32.28	995.8	71 51 40.57	941.1
Walnut Hill.	41 25 14.80	456.6	71 54 35.66	828.1
North Stonington.	41 25 59.53	1836.5	71 51 20.72	481.1
Eel's Hill. 1835.	41 22 50.15	1547.1	71 51 04.98	115.7
Ram Island Reef Spindle. 1835.	41 18 23.16	714.5	71 58 29.42	684.4
Stonington Meeting-house. 1835.	41 20 12.24	377.6	71 54 21.08	490.1
Ram Island house. 1835.	41 18 40.43	1247.2	71 58 45.50	1058.4
Portersville spire. 1835.	41 21 14.80	456.6	71 58 24.87	578.1
Turner's Reef Spindle. 1835.	41 19 00.00	0.0	71 57 20.19	469.6
Pine Island house chimney. 1835.	41 18 47.84	1475.8	72 03 34.84	810.4
Palmer, New London County.	41 21 37.29	1150.4	71 55 41.92	974.4
Atwood's Machine Works, cupola.	41 19 49.32	1521.5	71 54 26.23	610.0

RHODE ISLAND STATE LINE TO THAMES RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
289 29 57.1	109 31 58.5	Watch Hill ---- ---- ---- ----	4534.2	3.656499
47 42 54.3	227 38 46.8	Mount Prospect.	11800.0	4.071882
291 21 14.1	111 23 38.4	Champlin ---- ---- ---- ----	5422.6	3.734205
331 34 11.2	151 38 26.3	Wilcox.	18827.2	4.274787
243 38 12.2	63 44 20.8	Watch Hill ---- ---- ---- ----	14503.3	4.161466
284 08 58.8	104 25 30.8	Block Island.	36183.6	4.558512
285 27 39.3	105 33 51.4	Watch Hill ---- ---- ---- ----	13598.1	4.133477
359 22 01.0	179 22 04.2	Mount Prospect 2.	10066.1	4.002863
266 28 35.2	86 34 33.5	Watch Hill ---- ---- ---- ----	12648.0	4.102022
3 44 58.4	183 44 47.9	Mount Prospect 2.	5674.5	3.753927
290 46 35.3	110 48 37.0	Watch Hill ---- ---- ---- ----	4587.2	3.661549
47 15 36.5	227 11 29.5	Mount Prospect 2.	11864.3	4.074243
63 25 11.4	243 23 00.4	Stonington L. H., 1873 ---- ---- ----	5157.5	3.712438
4 42 40.8	184 42 31.6	Watch Hill.	3951.0	3.596705
271 26 17.9	91 31 39.1	Watch Hill ---- ---- ---- ----	11319.0	4.053809
14 02 25.9	194 01 38.3	Mount Prospect 2.	6928.4	3.840636
322 54 57	142 57 18	Watch Hill ---- ---- ---- ----	8254.3	3.91668
261 11 13	81 13 43	Eel's Hill 2.	5333.7	3.72703
45 01 12	224 59 18	Quacatog ---- ---- ---- ----	5666.8	3.75334
318 36 18	138 38 18	Eel's Hill 2.	6385.0	3.80516
73 09 00	253 05 47	Grant's Hill ---- ---- ---- ----	7061.9	3.84892
20 22 40	200 21 28	Eel's Hill 2.	7297.4	3.86317
63 10 13	243 06 54	Lantern Hill ---- ---- ---- ----	7808.7	3.89258
23 54 05	203 52 29	Grant's Hill.	8337.6	3.92104
42 01 01	221 59 27	Quacatog ---- ---- ---- ----	4961.0	3.69557
312 18 34	132 20 54	Eel's Hill 2.	6639.4	3.82213
356 16 58	176 17 09	Eel's Hill 2 ---- ---- ---- ----	5863.4	3.76815
323 05 37	143 07 23	Peleg Tiff.	6201.8	3.79252
74 17 15	254 10 55	Fort Hill ---- ---- ---- ----	13904.6	4.14316
2 11 50	182 11 42	Watch Hill.	7416.0	3.87017
92 28 43	272 27 29	Groton Long Point ---- ---- ----	2604.9	3.41579
145 36 38	325 35 11	Fort Hill.	5404.2	3.73273
223 04 52	43 07 02	Eel's Hill ---- ---- ---- ----	6671.4	3.82422
300 41 03	120 43 04	Watch Hill.	4973.5	3.69666
79 19 32	259 18 29	Groton Long Point ---- ---- ----	2267.8	3.35560
145 42 07	325 40 51	Fort Hill.	4753.4	3.67700
27 35 31	207 34 14	Groton Long Point ---- ---- ----	5847.2	3.76695
302 27 34	122 29 38	Wampasset.	5179.9	3.71432
272 04 29	92 08 29	Watch Hill ---- ---- ---- ----	8448.9	3.92680
76 21 01	256 19 01	Groton Long Point.	4335.3	3.63702
70 59 56	250 57 49	Goshen--- ---- ---- ---- ----	4751.5	3.67683
120 52 54	300 48 17	Manetuck.	8891.0	3.94895
309 57 52	130 00 47	Watch Hill ---- ---- ---- ----	8033.8	3.90492
77 38 01	257 34 44	Fort Hill 2.	7110.2	3.85188
46 11 22	226 07 18	Mount Prospect 2 ---- ---- ----	11924.2	4.07643
101 44 31	281 40 24	Fort Hill 2.	8891.4	3.94897

RHODE ISLAND STATE LINE TO THAMES RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Wilcox's Fish Works, brick chimney.	41 19 59.45	1834.0	71 57 13.04	303.2
Bluff Point.	41 18 53.97	1664.9	72 02 04.97	115.6
Noank spire. 1882.	41 19 33.76	1041.5	71 59 13.14	305.6
Prentis's house, white chimney.	41 19 21.19	653.7	72 01 54.08	1257.8
Ram Island Hotel flag-staff.	41 18 40.34	1244.4	71 58 46.45	1080.4
Avery's Point 2. 1882.	41 18 57.02	1759.0	72 03 52.68	1225.3

THAMES RIVER.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Vinegar Hill.	41 25 27.369	844.3	72 03 21.532	500.0
Tory.	41 31 04.441	137.0	72 04 05.329	123.6
Pole.	41 27 14.522	448.0	72 07 41.572	965.0
Quaker.	41 22 46.370	1430.5	72 06 26.048	605.2
Browning.	41 25 05.542	171.0	72 06 23.630	548.8
New London L. H. 1835–'86.	41 18 59.993	1850.8	72 05 24.685	574.2
Groton Monument.	41 21 18.018	555.9	72 04 47.454	1103.1
Mohican church spire. 1838.	41 28 23.880	736.7	72 05 55.306	1283.3
Quaker 2. 1869.	41 22 46.566	1436.6	72 06 26.028	604.8
Ogden.	41 23 48.290	1489.8	72 05 24.440	567.8
Quaker 3. 1874.	41 22 46.568	1436.6	72 06 26.050	605.3
Baldwin.	41 24 05.996	185.0	72 04 40.250	935.0
Maynard.	41 26 10.508	324.2	72 04 14.490	336.5
Uncas Hill.	41 28 14.897	459.6	72 05 27.624	641.0
Avery's Hill.	41 28 02.990	92.2	72 02 58.715	1362.5

RHODE ISLAND STATE LINE TO THAMES RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
28 50 59	208 48 45	Mount Prospect 2	9786.6	3.99063
107 11 41	287 09 24	Fort Hill 2.	5052.5	3.70351
270 24 53	90 32 01	Watch Hill	15068.2	4.17806
342 26 09	162 27 08	Mount Prospect 2.	6873.2	3.83716
276 55 07	97 00 21	Watch Hill	11151.9	4.04735
13 54 18	193 53 23	Mount Prospect 2.	8015.3	3.90392
308 18 12	128 19 14	Groton Long Point 2	2790.6	3.44570
346 09 53	166 10 45	Mount Prospect 2.	7614.5	3.88164
22 33 30	202 32 18	Mount Prospect 2	6640.3	3.82219
77 48 35	257 47 33	Groton Long Point 2.	2224.7	3.34727
232 33 21	52 35 18	Fort Hill 2	5623.4	3.75000
325 25 12	145 27 12	Mount Prospect 2.	8072.4	3.90700

THAMES RIVER.

348 20 37.8	168 22 27.2	Mount Prospect	19083.1	4.280649
246 33 03.2	66 37 28.3	Lantern Hill.	10136.8	4.005902
301 40 08.0	121 45 02.5	Lantern Hill	12120.9	4.083537
354 24 51.3	174 25 20.3	Vinegar Hill.	10448.3	4.019047
215 15 00.5	35 17 23.7	Tory	8687.9	3.938914
298 40 47.0	118 43 38.8	Vinegar Hill.	6882.8	3.837765
220 46 31.8	40 48 33.8	Vinegar Hill	6560.5	3.816938
168 02 10.9	348 01 21.1	Pole.	8456.4	3.927186
260 56 06.3	80 58 06.8	Vinegar Hill	4282.0	3.631647
0 44 58.7	180 44 57.1	Quaker.	4293.8	3.632843
315 03 40.5	135 06 51.0	Mount Prospect	9517.4	3.978518
173 04 43.9	353 04 04.9	Browning.	11360.0	4.055377
139 57 19.2	319 56 14.1	Quaker	3560.9	3.551555
162 20 58.2	342 19 54.6	Browning.	7366.2	3.867243
326 44 27.0	146 46 08.8	Vinegar Hill	6511.0	3.813647
6 08 08.9	186 07 50.2	Browning.	6154.0	3.789157
180 44 38.6	0 44 40.2	Browning	4287.8	3.632231
320 00 19.4	140 01 24.5	Groton Monument.	3565.2	3.552082
36 55 46.0	216 55 05.3	Quaker 2	2381.9	3.376919
150 01 35.1	330 00 56.0	Browning.	2751 4	3.439546
180 45 03.6	0 45 05.2	Browning	4287.7	3.632226
216 55 44.0	36 56 24.7	Ogden.	2382.1	3.376968
45 05 59.4	225 04 49.4	Quaker 3	3470.7	3.540421
127 25 42.1	307 24 33.7	Browning.	3023.2	3.480472
8 51 16.1	188 50 59.1	Baldwin	3887.5	3.589670
56 15 16.4	236 13 51.0	Browning.	3606.7	3.557111
336 07 52.4	156 08 40.8	Maynard	4196.1	3.622849
12 33 08.2	192 32 31.1	Browning.	5984.5	3.777031
26 53 06.6	206 52 16.4	Maynard	3890.4	3.589992
96 04 55.4	276 03 16.8	Uncas Hill.	3474.9	3.540943

THAMES RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Willow.	41 29 44.080	1359.9	72 04 28.798	667.9
Mound.	41 30 32.650	1007.3	72 05 13.432	311.5
Mason.	41 30 30.127	929.4	72 04 41.833	970.2
Cedar.	41 31 08.328	256.9	72 05 25.874	600.0
Fellows.	41 31 06.856	211.5	72 04 09.498	220.2
Jail Hill.	41 31 41.160	1269.8	72 04 49.148	1139.4
Falls Liberty Pole.	41 32 08.889	274.4	72 05 28.418	658.6
Upper Pole Hill.	41 27 14.378	443.6	72 07 41.128	954.6
Lower Pole Hill.	41 27 11.691	350.7	72 07 31.186	723.8
Uncasville church.	41 26 17.857	550.9	72 06 27.168	630.8
Bolles' Hill.	41 27 49.245	1519.2	72 04 43.038	998.7
Walden's Island.	41 28 06.552	202.1	72 04 08.328	193.3
Norman's barn.	41 28 33.168	1023.3	72 02 58.286	1352.4
Broadway church.	41 31 34.052	1050.5	72 04 33.646	780.1
Charleton's cupola.	41 31 41.224	1271.8	72 04 50.635	1173.9
White chimney.	41 26 28.371	875.3	72 05 45.462	1055.4
Cow Point.	41 24 32.326	997.3	72 05 33.939	788.3
Mohican church spire. 1874.	41 28 23.90	737.3	72 05 55.40	1285.4
Ledge.	41 25 07.39	228.0	72 05 17.74	411.9
South gable.	41 29 09.63	297.1	72 04 26.53	615.5
West 2. 1869.	41 24 04.40	135.7	72 05 55.66	1293.0
Red barn cupola.	41 25 52.68	1625.2	72 06 23.07	535.7
Yellow house chimney.	41 27 24.62	759.5	72 04 52.03	1207.6

THAMES RIVER—*Continued.*

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
326 09 49.8	146 10 49.5	Avery's Hill ---- ---- ---- ----	3754.2	3.574520
26 23 18.7	206 22 39.7	Uncas Hill.	3071.2	3.487312
325 21 22.7	145 21 52.3	Willow ---- ---- ---- ----	1821.2	3.260366
4 25 51.5	184 25 42.1	Uncas Hill.	4262.5	3.629662
347 59 04.1	167 59 12.7	Willow ---- ---- ---- ----	1454.4	3.162082
96 03 57.3	276 03 36.4	Mound.	736.9	2.867432
319 05 05.7	139 05 34.9	Mason ---- ---- ---- ----	1559.5	3.192974
345 18 40.6	165 18 48.8	Mound.	1137.9	3.056094
33 29 49.2	213 29 27.8	Mason ---- ---- ---- ----	1358.8	3.133141
54 33 47.0	234 33 04.6	Mound.	1819,8	3.260025
319 00 59.3	139 01 25.6	Fellows ---- ---- ---- ----	1401.8	3.146692
40 03 24.7	220 03 00.4	Cedar.	1323.3	3.121648
313 12 48.4	133 13 14.4	Jail Hill ---- ---- ---- ----	1249.2	3.096637
358 11 30.8	178 11 32.5	Cedar.	1869.2	3.271664
257 05 08.7	77 08 15.7	Avery's Hill ---- ---- ---- ----	6723.7	3.827605
324 07 41.4	144 09 41.1	Baldwin.	7170.4	3.855541
255 55 27.2	75 58 27.6	Avery's Hill ---- ---- ---- ----	6518.6	3.814153
325 16 05.4	145 17 58.5	Baldwin.	6969.4	3.843193
328 35 30.9	148 36 41.6	Baldwin ---- ---- ---- ----	4765.8	3.678134
236 08 41.8	56 10 59.8	Avery's Hill.	5824.9	3.765286
347 43 26.7	167 43 45.6	Maynard ---- ---- ---- ----	3117.3	3.493778
127 24 59.4	307 24 29.9	Uncas Hill.	1302.6	3.114815
2 17 18.2	182 17 14.1	Maynard ---- ---- ---- ----	3582.9	3.554230
97 58 18.8	277 57 26.3	Uncas Hill.	1858.0	3.269040
80 46 27.2	260 44 48.3	Uncas Hill ---- ---- ---- ----	3510.7	3.545394
0 36 42.5	180 36 42.2	Avery's Hill.	931.1	2.968990
56 46 00.5	236 45 25.9	Cedar ---- ---- ---- ---- ----	1447.8	3.160715
326 16 49.5	146 17 05.5	Fellows.	1008.6	3.003739
38 50 22.1	218 49 58.7	Cedar ---- ---- ---- ---- ----	1302.9	3.114904
318 01 19.7	138 01 47.0	Fellows.	1426.1	3.154165
19 07 52.3	199 07 27.0	Browning ---- ---- ---- ----	2704.6	3.432099
284 36 58.2	104 37 58.4	Maynard.	2182.7	3.338994
131 36 26.8	311 35 53.9	Browning ---- ---- ---- ----	1543.3	3.188462
350 46 24.9	170 46 31.2	Ogden.	1376.3	3.138721
326 43 47	146 45 29	Vinegar Hill ---- ---- ---- ----	6512.8	3.81377
6 06 58	186 06 39	Browning.	6154.7	3.78921
20 04 15	200 03 30	Quaker 3 ---- ---- ---- ----	4625.3	3.66514
87 51 52	267 51 08	Browning.	1531.3	3.18505
177 09 57	357 09 55	Willow ---- ---- ---- ----	1064.2	3.02702
357 06 10	177 06 18	Maynard.	5532.9	3.74295
304 25 36	124 25 57	Ogden ---- ---- ---- ----	879.1	2.94405
210 20 52	30 21 06	Cow Point.	998.3	2.99925
259 32 42	79 34 07	Maynard ---- ---- ---- ----	3035.6	3.48224
324 01 39	144 02 47	Baldwin.	4066.0	3.60917
339 08 02	159 08 27	Maynard ---- ---- ---- ----	2446.9	3.38861
26 22 25	206 21 24	Browning.	4788.7	3.68022

THAMES RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Teft's house.	41 29 51.52	1589.4	72 05 00.37	8.6
Flag-staff.	41 31 01.07	33.0	72 04 53.78	1247.0
Tory, bolt.	41 31 04.37	134.8	72 04 05.54	128.6
Woodruff's barn, south gable.	41 30 15.80	487.4	72 05 36.16	838.6
Spaulding's house, cupola.	41 30 28.99	894.4	72 05 14.01	324.9
School-house.	41 30 54.32	1675.8	72 04 32.55	754.7
Twin house cupola.	41 30 44.99	1388.0	72 04 58.70	1361.2
Rock.	41 31 10.98	338.7	72 04 13.18	305.6
Norwich church.	41 32 57.64	1778.2	72 05 46.78	1084.2
Park church.	41 32 07.87	242.8	72 04 55.05	1276.1
West Side church.	41 31 19.35	597.0	72 04 58.70	1361.0
Wharf.	41 23 38.46	1186.5	72 05 29.50	685.3
White flag.	41 24 22.44	692.3	72 05 36.14	839.5
Black cross.	41 24 09.68	298.6	72 05 35.95	835.1
White cross.	41 23 55.16	1701.7	72 05 33.53	778.9
Corner stone.	41 24 03.62	111.7	72 05 27.44	637.4
West 1. 1869.	41 23 28.90	891.6	72 05 45.30	1052.5
West 3. 1869.	41 24 26.68	823.1	72 05 54.99	1277.3
Bailey.	41 22 51.64	1593.1	72 04 56.93	1322.8
New London Presbyterian church spire. 1835.	41 21 18.61	574.1	72 05 50.02	1162.7
New London First Congregational church. 1882.	41 21 18.23	562.4	72 05 50.38	1171.0
New London Second Congregational church. 1882.	41 21 26.34	812.6	72 06 06.30	146.4
Fort Trumbull flag-staff. 1835.	41 20 38.28	1180.9	72 05 39.13	909.7
Fort Trumbull flag-staff. 1882.	41 20 38.28	1180.9	72 05 39.16	910.4

THAMES RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
166 34 44	346 34 35	Mound ---- ---- ---- ----	1304. 8	3. 11553
199 50 46	19 50 58	Mason.	1266. 5	3. 10261
343 48 59	163 49 07	Mason ---- ---- ---- ----	993. 9	2. 99733
27 28 18	207 28 05	Mound.	988. 1	2. 99478
129 56 47	309 56 44	Fellows ---- ---- ---- ----	119. 71	2. 07813
302 03 14	122 03 59	Willow ---- ---- ---- ----	1843. 7	3. 26568
250 40 01	70 40 37	Mason.	1335. 3	3. 12557
322 52 18	142 52 48	Willow ---- ---- ---- ----	1737. 5	3. 23992
267 17 45	87 18 06	Mason.	747. 1	2. 87337
54 48 28	234 48 01	Mound ---- ---- ---- ----	1160. 1	3. 06448
16 04 59	196 04 53	Mason.	776. 9	2. 89035
41 54 29	221 54 19	Mound ---- ---- ---- ----	511. 5	2. 70883
319 31 46	139 31 57	Mason.	602. 7	2. 78009
49 45 48	229 45 08	Mound ---- ---- ---- ----	1830. 4	3. 26254
326 06 47	146 06 49	Fellows.	153. 2	2. 18524
351 49 04	171 49 18	Cedar---- ---- ---- ---- ----	3406. 8	3. 53235
326 34 11	146 35 16	Fellows.	4094. 6	3. 61221
21 15 37	201 15 17	Cedar---- ---- ---- ---- ----	1971. 0	3. 29469
330 42 01	150 42 31	Fellows.	2158. 3	3. 33412
198 13 12	18 13 19	Jail Hill ---- ---- ---- ----	708. 5	2. 85034
288 39 23	108 39 56	Fellows.	1204. 2	3. 08070
201 11 20	21 11 23	Ogden ---- ---- ---- ----	325. 2	2. 51215
142 47 42	322 47 25	West 2.	1004. 8	3. 00208
39 10 40	219 10 27	West 2 ---- ---- ---- ----	717. 7	2. 85594
345 32 09	165 32 17	Ogden.	1087. 9	3. 03659
70 26 15	250 26 02	West 2 ---- ---- ---- ----	485. 9	2. 68651
337 56 41	157 56 49	Ogden.	711. 8	2. 85238
179 31 11	359 31 11	Cow Point ---- ---- ---- ----	1146. 7	3. 05945
119 01 22	299 01 07	West 2.	587. 9	2. 76928
92 06 43	272 06 24	West 2 ---- ---- ---- ----	655. 9	2. 81682
351 37 13	171 37 15	Ogden.	478. 0	2. 67944
219 00 53	39 01 07	Ogden ---- ---- ---- ----	769. 8	2. 88638
167 36 46	347 36 39	West 2.	1121. 3	3. 04971
329 03 53	149 04 13	Ogden ---- ---- ---- ----	1380. 6	3. 14006
250 22 40	70 22 54	Cow Point.	519. 1	2. 71524
62 36 02	242 33 19	Manetuck 2 ---- ---- ---- ----	6457. 0	3. 81003
85 41 16	265 40 17	Quaker 3.	2076. 4	3. 31732
88 49 04	268 46 56	Manetuck ---- ---- ---- ----	4490. 6	3. 65230
162 48 54	342 48 31	Quaker.	2833. 9	3. 45238
88 50 52	268 48 44	Manetuck 2 ---- ---- ---- ----	4490. 8	3. 65232
163 05 03	343 04 39	Quaker 3.	2848. 6	3. 45463
211 30 09	31 30 55	Bailey ---- ---- ---- ----	3086. 0	3. 48939
278 53 27	98 57 02	Fort Hill 2.	7663. 0	3. 88440
103 38 57	283 36 42	Manetuck ---- ---- ---- ----	4880. 5	3. 68846
164 34 45	344 34 14	Quaker.	4099. 2	3. 61270
103 30 55	283 28 40	Manetuck 2 ---- ---- ---- ----	4886. 3	3. 68898
321 34 47	141 35 57	Avery's Point 2.	3986. 1	3. 60055

THAMES RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Avery's barn, red topped cupola.	41 20 11.60	357.9	72 04 04.58	106.5
Avery's Hill, 2. 1882.	41 20 21.52	663.9	72 04 05.25	122.1
Groton Hill.	41 22 38.27	1180.6	72 04 54.20	1259.5
Beckwith's chimney.	41 20 32.12	990.9	72 06 37.12	863.0
Turner's (J.) house, white chimney.	41 21 23.77	733.3	72 03 41.54	965.6
Poor-house flag-staff.	41 21 08.51	262.5	72 06 41.80	971.7
Beacon.	41 18 48.03	1481.7	72 03 58.98	1371.9
Edgecombe house flag-staff.	41 19 31.46	970.5	72 04 31.67	736.5

THAMES RIVER TO CONNECTICUT RIVER.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Manetuck.	41 21 15.563	480.1	72 09 03.161	73.5
Four Mile River.	41 18 12.169	375.4	72 16 13.378	311.3
Black Point.	41 17 09.682	298.7	72 12 19.751	459.6
Hatchett's Point.	41 16 58.808	1814.2	72 15 43.526	1012.8
Goshen.	41 17 57.650	1778.5	72 06 47.936	1115.2
Chapin.	41 18 01.008	31.1	72 06 45.281	1053.5
Black Point 2. 1882.	41 17 11.776	363.3	72 12 17.366	404.1
Hatchett's Point 2. 1882.	41 17 03.526	108.8	72 15 45.752	1064.7
Manetuck 2. 1882.	41 21 15.256	470.6	72 09 03.526	81.9
Great Gull Island, N. Y.	41 12 06.426	198.2	72 07 06.210	144.7
Two Tree Island.	41 17 40.82	1259.3	72 09 11.98	278.8
Millstone Point.	41 18 18.92	583.7	72 09 54.44	1266.5
Lewis.	41 19 14.73	454.4	72 12 03.15	73.3

THAMES RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
40 09 17	220 08 24	New London L. H.	2889. 5	3. 46083
145 29 27	325 27 54	Quaker 3.	5802. 6	3. 76362
36 18 11	216 17 19	New London L. H.	3120. 7	3. 49425
103 28 14	283 24 57	Manetuck 2.	7130. 0	3. 85309
335 56 47	155 59 37	Mount Prospect	14752. 3	4. 16886
66 13 46	246 11 01	Manetuck.	6323. 8	3. 80098
208 24 30	28 25 36	Bailey	4893. 4	3. 68961
266 37 15	86 41 11	Fort Hill 2.	8301. 9	3. 91918
147 08 00	327 07 10	Bailey	3227. 2	3. 50882
284 45 05	104 47 04	Fort Hill 2.	4348. 1	3. 63830
93 37 38	273 36 04	Manetuck 2	3301. 2	3. 51867
186 53 54	6 54 04	Quaker 3.	3047. 1	3. 48389
207 51 31	27 51 35	Avery's Point 2	313. 7	2. 49650
100 29 28	280 28 31	New London L. H.	2027. 2	3. 30690
319 30 24	139 30 50	Avery's Point 2	1396. 9	3. 14518
51 48 02	231 47 27	New London L. H.	1569. 2	3. 19567

THAMES RIVER TO CONNECTICUT RIVER.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
225 35 06. 9	45 38 52. 8	Vinegar Hill	11106. 1	4. 045560
312 44 28. 9	132 50 03. 7	Mount Prospect.	16079. 2	4. 206264
240 28 20. 3	60 33 04. 4	Manetuck	11493. 6	4. 060456
283 28 51. 4	103 39 09. 9	Mount Prospect.	22443. 1	4. 351082
211 03 46. 2	31 05 56. 0	Manetuck	8856. 8	3. 947277
281 26 57. 4	101 34 41. 7	Mount Prospect.	16718. 4	4. 223194
229 34 42. 7	49 39 07. 0	Manetuck	12225. 0	4. 087250
265 56 03. 8	85 58 18. 2	Black Point.	4753. 9	3. 677046
299 03 19. 4	119 07 24. 8	Mount Prospect	9907. 6	3. 995970
79 10 48. 8	259 07 09. 8	Black Point.	7861. 2	3. 895487
299 44 40. 4	119 48 44. 1	Mount Prospect 2	9905. 2	3. 995864
265 13 37. 5	85 17 51. 8	Groton Long Point 2.	8995. 5	3. 954024
210 58 12. 1	31 00 20. 3	Manetuck	8772. 8	3. 943140
281 42 02. 9	101 49 45. 6	Mount Prospect 2.	16678. 0	4. 222144
266 58 35. 3	87 00 52. 8	Black Point 2	4855. 9	3. 686270
278 21 58. 9	98 31 59. 1	Mount Prospect 2.	21410. 7	4. 330631
312 41 25. 9	132 47 01. 0	Mount Prospect 2	16079. 2	4. 206264
30 59 25. 2	210 57 17. 2	Black Point 2.	8760. 4	3. 942522
236 27 26. 4	56 31 43. 6	Mount Prospect	10901. 6	4. 037490
170 52 58. 8	350 51 41. 7	Manetuck.	17157. 7	4. 234460
77 37 05	257 35 01	Black Point	4473. 5	3. 65065
181 46 21	1 46 27	Manetuck.	6627. 7	3. 82136
341 09 46	161 11 37	Gull Island	12140. 3	4. 08423
57 43 45	237 42 09	Black Point.	3999. 1	3. 60196
228 18 18	48 20 17	Manetuck 2	5591. 8	3. 74755
4 59 10	184 59 01	Black Point 2.	3807. 4	3. 58063

THAMES RIVER TO CONNECTICUT RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Niantic spire.	41 19 39.00	1203.1	72 11 35.04	814.9
Barn cupola (New London County).	41 19 35.15	1084.4	72 10 08.22	191.2
Two Tree Island 2. 1882.	41 17 39.16	1208.1	72 09 11.03	256.7
Chapin's house.	41 18 09.29	286.6	72 06 49.87	1160.2
Jordan church tower.	41 18 31.00	956.3	72 07 42.35	985.1
Millstone Point house, west chimney.	41 18 30.40	937.8	72 10 08.21	191.0
Millstone Point, single chimney.	41 18 19.71	608.0	72 09 53.24	1238.6
Two Tree Island house.	41 17 40.18	1239.5	72 09 11.37	264.6
New house chimney.	41 17 20.28	625.6	72 15 20.91	486.5
Four Mile River 2. 1882.	41 18 12.40	382.5	72 16 13.48	313.6
Rocky Ledge.	41 18 30.73	948.0	72 15 01.16	27.0
White house, west chimney.	41 17 22.59	696.9	72 16 21.92	510.0
Lone house chimney.	41 19 41.83	1290.4	72 07 01.78	41.4
Black Point house chimney.	41 17 12.58	388.1	72 12 17.60	409.5

CONNECTICUT RIVER.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
Beacon Hill 2. 1861.	41 17 34.630	1068.3	72 24 08.874	206.5
Lay's Hill 2. 1861.	41 16 58.200	1795.4	72 18 02.060	47.9
Cornfield Point.	41 15 42.215	1302.3	72 23 14.280	332.5
Ferry 2. 1861.	41 18 57.905	1786.3	72 21 57.005	1325.9
Saybrook L. H. 1861–'86.	41 16 17.390	536.5	72 20 36.864	857.9
Cornfield Point 2. 1882.	41 15 42.485	1310.6	72 23 14.728	342.9
Book Hill.	41 22 06.526	201.3	72 24 47.377	1101.2

THAMES RIVER TO CONNECTICUT RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
229 51 36	49 53 16	Manetuck 2	4607.2	3.66344
12 14 05	192 13 37	Black Point 2.	4646.9	3.66716
34 11 56	214 10 31	Black Point 2	5346.9	3.72810
76 44 57	256 43 41	Lewis.	2746.5	3.43878
78 59 15	258 57 12	Black Point 2	4416.9	3.64512
126 22 57	306 21 03	Lewis.	4973.0	3.69662
76 55 16	256 51 40	Black Point 2	7823.7	3.89341
151 33 48	331 32 20	Manetuck 2.	6525.3	3.81460
102 33 45	282 30 53	Lewis	6214.4	3.79340
159 34 29	339 33 35	Manetuck 2.	5407.5	3.73300
51 06 17	231 04 52	Black Point 2	3861.7	3.58678
117 06 10	297 04 54	Lewis.	3003.0	3.47756
58 00 43	237 59 08	Black Point 2	3954.3	3.59707
119 20 16	299 18 50	Lewis.	3465.9	3.53981
78 34 20	258 32 17	Black Point 2	4415.8	3.64501
126 08 33	306 06 40	Lewis.	4947.3	3.69437
273 29 44	93 31 45	Black Point 2	4279.1	3.63135
48 12 44	228 12 28	Hatchett's Point 2.	775.3	2.88947
343 06 03	163 06 21	Hatchett's Point 2	2220.6	3.34648
59 57 34	239 54 40	Saybrook L. H., 1861.	7082.1	3.85016
302 34 06	122 35 54	Black Point 2	4522.7	3.65540
21 05 40	201 05 11	Hatchett's Point 2.	2883.2	3.45988
304 56 09	124 56 33	Hatchett's Point 2	1026.7	3.01143
71 53 34	251 52 28	Lay's Hill 3.	2446.5	3.38854
135 31 37	315 30 17	Manetuck 2	4039.7	3.60635
188 17 18	8 17 42	Quaker 3.	5759.3	3.76037
185 05 39	5 05 49	Lewis	3782.4	3.57777
211 04 09	31 06 17	Manetuck 2.	8742.8	3.94165

CONNECTICUT RIVER.

208 07 53.6	28 10 51.5	Nickerson	13269.0	4.122839
125 18 34.6	305 13 56.8	Williams.	11984.0	4.078600
169 58 59.7	349 57 55.3	Nickerson	13021.5	4.114660
97 32 02.9	277 28 00.9	Beacon Hill 2.	8609.3	3.934967
159 52 50.6	339 52 14.8	Beacon Hill 2	3693.4	3.567428
252 05 33.8	72 08 59.9	Lay's Hill 2.	7635.5	3.882839
199 16 28.9	19 17 59.7	Nickerson	9672.7	3.985547
304 01 15.7	124 03 50.8	Lay's Hill 2.	6596.6	3.819320
115 47 52.4	295 45 32.4	Beacon Hill 2	5479.2	3.738715
159 22 20.2	339 21 27.2	Ferry 2.	5291.3	3.723566
159 59 14.0	339 58 37.7	Beacon Hill 2	3681.9	3.566077
196 41 25.7	16 42 16.4	Ferry 2.	6293.9	3.798920
245 07 54.5	65 11 18.0	Nickerson	7881.6	3.896612
315 13 18.3	135 17 46.0	Lay's Hill 2.	13391.2	4.126820

CONNECTICUT RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Malicah.	41 20 35.166	1084.9	72 20 09.230	214.6
Bog Hole Hill 2. 1861.	41 18 49.736	1534.3	72 18 56.953	1324.8
Lay's Hill 3. 1882.	41 16 57.926	1786.9	72 18 01.838	42.8
Beacon Hill 3. 1882.	41 17 34.378	1060.5	72 24 09.316	216.8
Saybrook Breakwater L. H. 1886.	41 15 47.689	1471.2	72 20 35.445	825.1
Mount Parnassus.	41 28 03.613	111.5	72 24 40.537	940.7
Thayer.	41 31 55.851	1723.0	72 35 07.144	165.6
Long Hill.	41 26 45.491	1403.4	72 30 24.968	579.6
Chestnut Hill.	41 31 27.382	844.7	72 25 53.556	1241.7
Pine Hill.	41 36 37.635	1161.1	72 32 11.980	277.4
Westfield.	41 33 31.168	961.6	72 42 34.149	791.3
School-house Hill.	41 39 31.321	966.3	72 40 52.913	1224.2
Kongscut.	41 41 44.351	1368.3	72 30 10.150	234.7
Talcott.	41 48 41.637	1284.6	72 47 57.186	1320.0
Beacon Hill.	41 17 34.65	1068.9	72 24 08.85	205.9
Lay's Hill.	41 16 58.26	1797.3	72 18 02.04	47.5
Bog Hole Hill.	41 18 49.74	1534.4	72 18 56.90	1323.5
Essex.	41 20 33.36	1029.2	72 23 49.09	1141.3
Ferry.	41 18 57.92	1786.8	72 21 56.98	1325.4
Pettipaug spire.	41 21 05.94	183.2	72 24 53.38	1240.9
Essex Episcopal church spire. 1838.	41 21 11.72	361.6	72 23 35.95	835.7
Stone Hill.	41 19 54.15	1670.5	72 24 11.31	263.0
Bald Hill.	41 27 43.10	1329.6	72 25 06.86	159.2

CONNECTICUT RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
186 24 58.9	6 25 18.5	Nickerson	6168.0	3.790146
95 05 18.6	274 58 02.3	Williams.	15410.8	4.187825
72 19 14.0	252 15 48.1	Beacon Hill 2	7617.5	3.881811
173 58 41.1	353 58 12.9	Nickerson.	9434.0	3.974694
266 51 55.0	86 53 24.8	Hatchett's Point 2	3171.6	3.501276
266 55 02.7	86 58 50.0	Black Point 2.	8027.5	3.904580
295 38 23.3	115 40 43.5	Saybrook L. H., 1861	5484.9	3.739170
339 47 14.6	159 47 50.6	Cornfield Point 2.	3678.1	3.565626
250 50 15.6	70 53 26.7	Hatchett's Point 2	7136.8	3.853505
257 20 27.9	77 25 56.5	Black Point 2.	11879.1	4.074782
0 49 36.6	180 49 32.1	Book Hill	11017.3	4.042077
317 45 59.8	137 49 19.0	Nickerson.	10402.2	4.017124
296 11 03.9	116 17 59.1	Mount Parnassus	16203.6	4.209610
304 33 03.7	124 43 17.9	Nickerson.	26162.6	4.417680
145 40 01.4	325 36 54.5	Thayer	11598.5	4.064401
289 23 57.2	109 31 04.2	Nickerson.	15895.5	4.201273
35 55 51.5	215 52 51.7	Long Hill	10736.6	4.030868
93 57 56.9	273 51 49.9	Thayer.	12864.4	4.109388
317 28 25.9	137 32 37.0	Chestnut Hill	12980.5	4.113292
25 02 26.7	205 00 30.5	Thayer.	9593.9	3.981996
248 10 56.9	68 17 49.9	Pine Hill	15517.5	4.190822
285 48 14.9	105 53 11.4	Thayer.	10769.8	4.032208
293 54 45.4	114 00 31.5	Pine Hill	13194.5	4.120394
1 55 20.9	191 54 13.7	Westfield.	11355.7	4.055214
16 36 03.1	196 34 42.1	Pine Hill	9873.6	3.994476
74 37 38.0	254 30 30.6	School-house Hill.	15423.6	4.188187
272 28 35.8	92 42 19.6	Box Hill	28556.7	4.455708
329 57 15.8	150 01 58.2	School-house Hill.	19606.0	4.292390
208 07 51	28 10 49	Nickerson	13268.4	4.12282
225 00 08	45 02 46	Malicah.	7878.3	3.89643
97 31 31	277 27 29	Beacon Hill	8609.1	3.93496
169 58 46	349 57 42	Nickerson.	13020.3	4.11462
72 19 36	252 16 10	Beacon Hill	7618.3	3.88186
152 39 26	332 38 38	Malicah.	3661.5	3.56366
223 07 58	43 10 43	Nickerson	8478.5	3.92832
269 21 22	89 23 47	Malicah.	5112.0	3.70859
138 29 09	318 27 55	Essex	3932.5	3.59467
219 51 42	39 52 53	Malicah.	3908.7	3.59203
234 35 08	54 38 35	Nickerson	8945.2	3.95159
278 09 14	98 12 22	Malicah.	6673.8	3.82437
227 40 30	47 42 06	Nickerson	7429.5	3.87096
283 11 00	103 13 16	Malicah.	4936.4	3.69341
220 28 35	40 31 35	Nickerson	9725.0	3.98789
257 18 28	77 21 08	Malicah.	5769.3	3.76112
312 54 44	132 58 21	Nickerson	10381.4	4.01626
357 30 10	177 30 23	Book Hill.	10393.2	4.01675

CONNECTICUT RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Essex 2. 1861.	41 20 33.33	1028.2	72 23 49.09	1141.3
Honey Hill.	41 23 49.83	1537.2	72 21 34.38	798.7
Lord.	41 21 30.88	952.6	72 20 47.42	1102.3
Doane.	41 22 27.19	838.8	72 24 47.58	1105.7
Selden.	41 24 20.24	624.4	72 24 02.76	64.1
Brooks.	41 25 24.26	748.4	72 25 42.99	998.2
Cone.	41 24 38.76	1195.7	72 26 52.80	1226.4
Wahginnicut.	41 23 43.60	1345.1	72 25 45.92	1066.8
Holt.	41 25 41.32	1274.7	72 27 29.89	694.0
Cedar.	41 22 41.98	1295.1	72 23 40.05	930.6
Gelston.	41 26 57.58	1776.3	72 26 31.49	730.9
Noyes.	41 18 59.61	1838.9	72 20 33.18	771.8
Emmons.	41 32 06.35	195.9	72 32 07.63	176.9
Paphro.	41 28 40.41	1246.6	72 31 30.35	704.2
Ely 3. 1861.	41 21 52.97	1634.1	72 22 24.74	575.0
Ely 2. 1861.	41 21 51.48	1588.1	72 22 27.19	631.9
Gravel Bluff.	41 19 20.44	630.6	72 21 05.84	135.8
Jones.	41 27 59.34	1830.6	72 27 32.46	753.3
Brainerd.	41 29 18.49	570.4	72 31 35.95	834.0
Smith.	41 30 32.05	988.8	72 30 55.32	1282.9
Moodus.	41 31 13.47	415.6	72 27 32.64	756.8
Shaler.	41 27 47.93	1478.7	72 29 00.93	21.6
Selden North.	41 30 50.16	1547.5	72 31 30.07	697.2

CONNECTICUT RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		Metres.	
223 07 38	43 10 23	Nickerson	8479.3	3.92836
269 20 38	89 23 03	Malicah.	5112.1	3.70860
341 45 11	161 46 07	Malicah	6323.0	3.80092
54 37 05	234 34 57	Book Hill.	5501.4	3.74047
101 10 42	281 08 03	Book Hill	5684.6	3.75470
165 43 20	345 42 49	Honey Hill.	4423.3	3.64575
240 23 09	60 25 17	Honey Hill	5162.4	3.71285
298 04 49	118 07 53	Malicah.	7335.2	3.86541
285 12 45	105 14 23	Honey Hill	3572.0	3.55291
14 06 43	194 06 14	Book Hill.	4252.8	3.62868
296 44 51	116 47 35	Honey Hill	6467.4	3.81073
346 44 06	166 44 43	Doane.	5612.3	3.74914
203 22 46	23 23 56	Bald Hill	6196.1	3.79212
278 13 01	98 14 53	Selden.	3990.6	3.60104
137 36 55	317 36 11	Cone	2304.2	3.36252
181 15 16	1 15 18	Brooks.	3106.1	3.49221
221 27 27	41 29 02	Bald Hill	5013.8	3.70017
297 27 27	117 29 44	Selden.	5422.0	3.73416
234 20 57	54 22 20	Honey Hill	3592.6	3.55541
308 34 51	128 37 10	Malicah.	6270.2	3.79728
234 25 59	54 26 55	Bald Hill	2414.6	3.38285
6 35 34	186 35 20	Cone.	4311.0	3.63458
316 47 55	136 49 35	Lay's Hill 2	5137.1	3.71072
62 25 59	242 23 37	Beacon Hill 2.	5661.5	3.75293
346 27 46	166 28 54	Long Hill	10181.5	4.00781
85 34 08	265 32 09	Thayer.	4174.1	3.62056
140 11 44	320 09 20	Thayer	7850.5	3.89490
172 15 18	352 14 53	Emmons.	6411.9	3.80699
197 58 49	17 59 22	Honey Hill	3790.4	3.57868
286 45 25	106 46 29	Lord.	2362.5	3.37337
352 31 46	172 32 06	Ferry 2	5400.6	3.73244
38 18 12	218 17 18	Essex 2.	3072.0	3.48742
120 39 13	300 37 25	Essex 2	4412.1	3.64465
157 54 46	337 53 52	Ely 2.	5028.8	3.70146
278 25 19	98 26 55	Bald Hill	3415.9	3.53351
323 23 47	143 24 27	Gelston.	2373.1	3.37532
134 46 02	314 43 42	Thayer	6896.2	3.83861
171 55 38	351 55 17	Emmons.	5230.5	3.71854
13 16 48	193 16 25	Paphro	3538.6	3.54883
113 54 23	293 51 36	Thayer.	6385.6	3.80520
74 48 34	254 46 20	Smith	4870.6	3.68758
97 06 55	277 01 54	Thayer.	10618.2	4.02605
152 20 57	332 19 41	Smith	5716.4	3.75712
197 53 31	17 54 29	Moodus.	6663.6	3.82371
111 57 07	291 54 43	Thayer	5425.8	3.73446
159 40 19	339 39 54	Emmons.	2506.4	3.39905

CONNECTICUT RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Swan Hill.	41 30 09.02	278.3	72 33 31.89	739.6
Arnold's Quarry.	41 28 26.06	804.0	72 30 28.54	662.2
Haddam Neck.	41 28 55.33	1706.9	72 29 28.36	658.0
Salmon.	41 28 19.33	596.3	72 28 00.52	12.1
Ayer.	41 19 55.92	1725.1	72 21 38.38	892.5
Beckwith.	41 21 12.50	385.6	72 21 23.04	535.5
Beckwith Hill, flag in tree.	41 36 32.94	1016.2	72 38 56.56	1309.6
Brockway.	41 23 23.64	729.3	72 23 18.73	435.2
Buckingham.	41 22 56.35	1738.4	72 23 47.90	1112.9
Chester Landing.	41 24 50.52	1558.5	72 25 45.96	1067.3
Chester spire.	41 24 04.64	143.1	72 27 15.16	352.2
Deep River spire.	41 23 12.14	374.5	72 26 04.78	111.1
East Haddam Congregational church.	41 28 49.29	1520.6	72 26 48.97	1136.1
East Haddam Episcopal church.	41 27 37.70	1163.0	72 27 33.73	782.8
Essex Congregational church.	41 21 09.96	307.3	72 23 34.24	795.9
Essex Baptist church.	41 21 18.26	563.3	72 23 33.57	780.3
Essex Episcopal church. 1861.	41 21 11.08	341.8	72 23 32.43	753.9
Ely's wharf.	41 21 48.10	1483.9	72 22 35.56	826.4
Grassy Hill church.	41 23 45.56	1405.5	72 17 16.50	383.3
Hadlyme church cupola.	41 25 53.58	1652.9	72 24 21.36	496.0
Joe Post's Light. 1861.	41 23 20.35	627.8	72 25 05.28	122.7
Pilgrim.	41 19 49.60	1530.2	72 20 27.46	638.6
Wahginnicut flag-staff. 1861.	41 23 43.03	1327.5	72 25 39.17	910.0

CONNECTICUT RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
245 47 22	65 48 43	Selden North	3097.4	3.49100
300 05 06	120 06 23	Brainerd.	3108.4	3.49254
135 04 28	315 01 23	Thayer	9145.8	3.96122
161 19 38	341 18 32	Emmons.	7174.1	3.85577
103 35 01	283 33 37	Brainerd	3045.1	3.48360
111 56 33	291 53 52	Swan Hill.	6089.5	3.78458
55 21 21	235 20 41	Shaler	1704.0	3.23147
110 04 40	290 02 17	Brainerd.	5320.8	3.72598
239 42 29	59 43 28	Malicah	2400.7	3.38033
13 36 07	193 35 55	Ferry 2.	1841.3	3.26513
10 46 00	190 45 38	Ferry 2	4226.7	3.62600
70 25 07	250 23 31	Essex 2.	3604.2	3.55681
269 04 36	89 09 05	Pine Hill	9369.1	3.97170
41 58 07	221 55 43	Westfield.	7540.5	3.87740
251 33 22	71 34 31	Honey Hill	2555.4	3.40746
21 04 29	201 04 15	Cedar.	1377.4	3.13906
241 58 58	62 00 26	Honey Hill	3513.6	3.54575
302 08 20	122 10 19	Lord.	4954.4	3.69499
291 17 00	111 18 08	Selden	2572.5	3.41036
76 51 16	256 50 32	Cone.	1594.2	3.20254
221 03 53	41 04 54	Brooks	3258.4	3.51300
273 16 15	93 20 00	Honey Hill.	7929.4	3.89924
233 26 38	53 27 59	Selden	3528.4	3.54758
259 29 14	79 32 13	Honey Hill.	6388.8	3.80542
310 44 44	130 45 52	Bald Hill	3128.0	3.49527
9 18 18	189 17 51	Holt.	5876.2	3.76910
310 04 56	130 08 54	Honey Hill	10910.4	4.03784
358 34 36	178 34 39	Holt.	3591.4	3.55526
227 08 43	47 11 18	Nickerson	7436.7	3.87138
282 40 24	102 42 39	Malicah.	4885.4	3.68890
228 32 41	48 35 16	Nickerson	7253.5	3.86055
285 36 48	105 39 03	Malicah.	4932.8	3.69309
230 34 52	50 35 35	Ely 2	1962.9	3.29290
283 10 59	103 13 13	Malicah.	4852.6	3.68597
350 18 22	170 18 47	Ferry 2	5326.5	3.72644
36 32 38	216 31 49	Essex 2.	2870.8	3.45801
4 49 17	184 48 47	Lay's Hill 2	12611.3	4.10076
57 00 46	236 56 27	Essex 2.	10882.0	4.03671
351 28 10	171 28 22	Selden	2912.1	3.46420
56 44 04	236 42 24	Cone.	4206.7	3.62394
127 13 05	307 12 38	Wahginnicut	1185.4	3.07387
167 05 52	347 05 27	Brooks.	3922.2	3.59353
52 33 56	232 32 57	Ferry 2	2623.0	3.41880
106 04 18	286 02 05	Essex 2.	4878.7	3.68830
178 22 23	358 22 20	Brooks	3123.9	3.49470
242 50 38	62 51 42	Selden.	2516.9	3.40087

CONNECTICUT RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Champion House flag-staff.	41 27 42.76	1319.2	72 27 53.32	1237.4
Joshua Rock.	41 22 51.84	1599.3	72 22 37.80	878.3
Locust.	41 25 02.22	68.5	72 27 17.72	411.5
Lyme white Congregational church. 1835–'83.	41 18 46.45	1433.0	72 19 56.04	1303.5
Pine Island.	41 20 26.14	806.4	72 20 50.95	1184.6
Quarry.	41 24 26.72	824.3	72 25 17.11	397.4
Selden Neck.	41 23 43.05	1328.1	72 24 54.72	1271.2
Williams' Dock.	41 21 37.88	1168.6	72 23 28.60	664.7
Lord's Island, flag in tree.	41 26 09.40	290.0	72 27 02.30	53.4
Hamburgh Cove.	41 22 36.66	1130.9	72 22 21.00	488.0
Hayden's Point.	41 20 37.22	1148.2	72 22 38.52	895.5
Higgins' wharf.	41 19 31.01	956.6	72 20 33.41	777.0
Clark, flag in tree.	41 27 12.12	373.9	72 28 08.44	195.9
Haddam Academy.	41 28 44.81	1382.4	72 30 59.76	1386.5
Haddam Congregational church.	41 28 45.82	1413.5	72 30 56.05	1300.5
Haddam Court House.	41 28 50.68	1563.5	72 31 00.62	14.4
Haddam Neck Congregational church.	41 31 47.50	1465.4	72 32 13.46	312.0
Haddam Neck Methodist church.	41 30 54.47	1680.4	72 30 53.26	1235.0
Haddam Neck flag.	41 29 37.60	1160.0	72 30 30.18	700.1
Higganum Congregational church.	41 29 51.13	1577.4	72 33 20.29	470.6
Higganum Methodist church.	41 29 54.66	1686.3	72 33 49.49	1147.9
Penfield Hill.	41 34 54.05	1667.5	72 34 29.77	689.6
Rock Landing, flag in tree.	41 29 48.66	1501.2	72 31 19.88	461.1

CONNECTICUT RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
95 49 11	275 48 26	Shaler	1577.0	3.19782
135 26 09	315 25 06	Haddam Neck.	3143.0	3.49734
78 07 41	258 07 00	Cedar	1478.0	3.16968
219 28 06	39 28 48	Honey Hill.	2317.8	3.36507
285 36 47	105 40 34	Honey Hill	8281.3	3.91810
323 53 07	143 54 46	Doane.	5919.7	3.77230
321 30 57	141 32 12	Lay's Hill	4263.2	3.62974
69 23 06	249 20 19	Beacon Hill.	6284.8	3.79829
29 26 34	209 25 50	Ferry 2	3125.9	3.49497
93 04 39	273 02 41	Essex 2.	4147.8	3.61782
99 29 35	279 28 32	Cone	2253.3	3.35282
161 17 30	341 17 13	Brooks.	1873.8	3.27273
355 56 42	175 56 47	Doane	2346.3	3.37038
90 49 15	270 48 41	Wahginnicut.	1189.5	3.07537
213 05 40	33 06 56	Honey Hill	4859.5	3.68659
273 17 09	93 18 56	Lord.	3752.7	3.57434
36 28 48	216 28 30	Holt	1077.7	3.03248
137 50 34	317 49 15	Shaler.	4101.5	3.61294
313 00 20	133 01 22	Lord	2974.5	3.47342
28 17 39	208 16 41	Essex 2.	4320.6	3.63554
186 33 09	6 33 16	Ely 2	2306.2	3.36290
271 01 55	91 03 34	Malicah.	3471.7	3.54054
62 17 33	242 16 38	Ferry 2	2196.1	3.34165
148 36 34	328 35 19	Ely 2.	5077.0	3.70561
132 12 08	312 11 33	Shaler	1644.4	3.21602
185 03 55	5 04 00	Salmon.	2081.5	3.31837
141 04 11	321 03 47	Brainerd	1335.7	3.12572
261 17 13	81 18 14	Haddam Neck.	2145.3	3.33149
78 09 21	258 08 58	Paphro	813.2	2.91020
137 26 12	317 25 46	Brainerd.	1368.5	3.13623
315 34 18	135 34 39	Arnold's Quarry	1063.8	3.02686
65 21 38	245 21 18	Paphro.	759.0	2.88027
330 21 58	150 22 27	Selden North	2035.0	3.30856
93 40 39	273 38 44	Thayer.	4034.8	3.60582
262 48 03	82 50 16	Moodus	4688.7	3.67105
3 57 31	183 57 30	Smith.	693.3	2.84095
38 21 34	218 20 54	Paphro	2249.7	3.35212
68 53 00	248 52 16	Brainerd.	1635.3	3.21360
154 00 00	333 59 52	Swan Hill	613.8	2.78801
234 31 13	54 32 26	Selden North.	3138.8	3.49676
242 04 52	62 06 24	Selden North	3658.9	3.56335
254 02 55	74 04 50	Smith.	4200.9	3.62334
339 20 23	159 23 05	Long Hill	16106.8	4.20701
8 57 36	188 57 11	Thayer.	5564.8	3.74545
334 56 26	154 57 00	Arnold's Quarry.	2813.1	3.44918
6 35 16	186 35 09	Paphro.	2119.1	3.32615

CONNECTICUT RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Parker's Point, flag in tree.	41 25 43.74	1349.4	72 26 31.00	719.8
Shailerville Baptist church.	41 27 55.48	1711.6	72 28 47.96	1112.9
Smith's Landing.	41 29 07.76	239.4	72 30 26.30	610.1
Walkley.	41 29 42.40	1308.1	72 32 02.09	48.5
Walkley's house.	41 29 30.20	931.7	72 31 56.66	1314.2
Westchester Hill, flag in tree.	41 31 26.15	806.7	72 25 53.53	1241.1
Saybrook L. H. 1835–'36.	41 16 17.65	544.5	72 20 36.94	859.8
Saybrook Congregational church. 1835.	41 17 12.34	380.7	72 22 34.08	793.0
Saybrook Beacon. 1835.	41 16 08.06	248.6	72 20 19.30	449.3
Steens.	41 37 19.70	607.8	72 40 47.26	1094.0
Tryon.	41 32 40.58	1251.9	72 37 37.73	874.6
Shipman.	41 40 16.02	494.2	72 38 14.37	332.3
Simpson.	41 37 58.08	1791.8	72 36 47.82	1106.9
Taylor.	41 40 19.05	587.7	72 35 25.38	587.1
Insane Asylum, northwest chimney.	41 33 08.02	247.4	72 37 50.08	1160.6
Middletown South Congregational church.	41 33 23.25	717.3	72 38 51.74	1199.0
Middletown Wesleyan College chapel.	41 33 20.72	639.2	72 39 23.04	533.9
Middletown Indian Hill Cemetery, summer-house.	41 33 17.08	526.9	72 39 48.19	1116.8
Middletown North Congregational church.	41 33 36.59	1128.8	72 39 05.42	125.6
Middletown Catholic church.	41 33 59.08	1822.6	72 39 11.92	276.2
Portland Scheider's factory smoke-stack.	41 34 14.78	456.0	72 37 45.68	1058.4
Portland white steeple.	41 34 53.00	1635.1	72 38 03.12	72.3
Portland Congregational church.	41 35 28.58	881.7	72 37 29.55	684.4

CONNECTICUT RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
137 45 46	317 44 07	Shaler ---- ---- ---- ----	5175.8	3.71398
179 42 43	359 42 43	Gelston.	2277.6	3.35748
153 04 54	333 04 27	Haddam Neck ---- ---- ---- ----	2071.1	3.31620
236 14 29	56 15 00	Salmon.	1324.4	3.12201
2 18 12	182 18 11	Arnold's Quarry ---- ---- ----	1287.6	3.10978
60 25 54	240 25 12	Paphro.	1708.8	3.23268
133 49 52	313 47 49	Thayer ---- ---- ---- ----	5946.9	3.77429
178 20 34	358 20 30	Emmons.	4442.8	3.64766
216 42 20	36 43 01	Smith ---- ---- ---- ---- ----	2380.2	3.37661
338 19 33	158 19 50	Paphro.	1652.8	3.21821
56 49 38	236 45 55	Paphro ---- ---- ---- ----	9336.8	3.97020
94 08 11	274 02 04	Thayer.	12867.1	4.10948
73 23 52	253 22 08	Cornfield Point ---- ---- ---- ----	3821.3	3.58221
115 43 56	295 41 36	Beacon Hill.	5474.2	3.73832
18 36 02	198 35 35	Cornfield Point ---- ---- ---- ----	2933.2	3.46734
107 20 05	287 19 02	Beacon Hill.	2310.6	3.36372
78 56 23	258 54 28	Cornfield Point ---- ---- ---- ----	4149.9	3.61804
116 34 59	296 32 28	Beacon Hill.	5972.8	3.77618
178 09 17	358 09 13	School-house Hill ---- ---- ----	4062.7	3.60882
276 09 38	96 15 20	Pine Hill.	12000.2	4.07919
102 49 37	282 46 20	Westfield ---- ---- ---- ----	7044.5	3.84785
153 00 11	332 58 05	Steens.	9665.8	3.98524
308 44 30	128 48 31	Pine Hill ---- ---- ---- ----	10758.7	4.03176
25 44 22	205 41 29	Westfield.	13862.8	4.14185
44 16 47	224 12 57	Westfield ---- ---- ---- ----	11496.1	4.06055
77 58 18	257 55 39	Steens.	5666.7	3.75333
38 18 38	218 13 53	Westfield ---- ---- ---- ----	16028.0	4.20488
79 02 04	258 58 26	School house Hill.	7720.1	3.88762
152 09 04	332 07 07	Steens ---- ---- ---- ----	8782.3	3.94361
230 25 18	50 29 02	Pine Hill.	10158.0	4.00681
159 52 01	339 50 44	Steens---- ---- ---- ---- ----	7770.0	3.89042
237 02 01	57 06 26	Pine Hill.	11032.4	4.04267
94 10 51	274 08 44	Westfield ---- ---- ---- ----	4440.2	3.64740
165 11 15	345 10 19	Steens.	7626.7	3.88234
169 38 48	349 38 09	Steens ---- ---- ---- ---- ----	7608.8	3.88132
239 36 33	59 41 36	Pine Hill.	12245.9	4.08799
161 05 32	341 04 24	Steens ---- ---- ---- ----	7276.1	3.86190
239 42 32	59 47 06	Pine Hill.	11086.4	4.04479
79 36 23	259 34 09	Westfield ---- ---- ---- ----	4764.3	3.67800
160 22 10	340 21 07	Steens.	6571.4	3.81766
78 38 49	258 35 36	Westfield ---- ---- ---- ----	6818.0	3.83366
143 37 05	323 35 04	Steens.	7087.6	3.85050
68 07 20	248 04 20	Westfield ---- ---- ---- ----	6767.7	3.83044
139 59 06	319 57 17	Steens.	5910.2	3.77160
62 51 23	242 48 01	Westfield ---- ---- ---- ----	7932.0	3.89938
147 51 51	327 49 36	School-house Hill.	8845.9	3.94674

CONNECTICUT RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Cromwell Congregational church.	41 35 48.75	1504.0	72 38 46.76	1083.0
Drum Hill, flag in tree.	41 38 54.22	1672.7	72 38 40.07	927.2
North Glastonbury Congregational church.	41 42 31.86	982.9	72 36 31.92	738.0
Wethersfield flag-staff. 1875.	41 42 45.90	1416.1	72 39 10.97	253.6
Wethersfield white Congregational church.	41 42 46.70	1440.8	72 39 09.60	221.9
Hartford, Colt's factory.	41 45 24.28	749.1	72 39 48.90	1129.7
Hartford, old State-House cupola.	41 45 58.03	1790.3	72 40 23.38	540.1
Hartford, Arsenal flag-staff.	41 46 51.85	1599.7	72 40 34.00	785.2
Hartford, Windsor Avenue church.	41 46 56.74	1750.5	72 40 33.74	779.2
Wadsworth's tower. 1875.	41 49 25.60	789.8	72 47 56.82	1311.2
Wadsworth's tower. 1862–'63.	41 49 15.81	487.8	72 47 55.24	1274.8
East Hartford, square steeple, with green blinds.	41 46 08.56	264.1	72 38 41.38	955.8
Saybrook Congregational church. 1861–'83.	41 17 12.20	376.4	72 22 32.29	751.4
Saybrook beacon. 1882–'83.	41 16 07.50	231.4	72 20 18.70	435.3
Hartford South Congregational church.	41 45 34.82	1074.2	72 40 33.35	770.4
Fenwick Hall flag-staff.	41 16 20.43	630.2	72 21 15.03	349.8
Griswold Point flag.	41 16 39.84	1229.0	72 19 25.61	596.0
Hummock, flag in tree.	41 17 59.60	1838.6	72 20 20.66	480.7
Oyster Reef, flag in tree.	41 16 30.56	942.7	72 23 12.89	300.0
Back River flag.	41 17 17.86	551.0	72 19 24.67	574.0
Ingraham's house, chimney.	41 17 13.78	425.1	72 23 21.66	504.0
Guard-House Point, chimney.	41 15 51.14	1577.6	72 22 04.12	95.9
Ely.	41 21 51.48	1588.2	72 22 27.20	632.1

CONNECTICUT RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
260 35 41	80 40 03	Pine Hill ---- ---- ---- ----	9265.5	3.96687
51 09 42	231 07 11	Westfield.	6764.9	3.83026
28 33 41	208 31 06	Westfield ---- ---- ---- ----	11344.9	4.05480
45 16 48	225 15 23	Steens.	4144.4	3.61746
279 23 29	99 27 43	Kongscut ---- ---- ---- ----	8948.7	3.95176
47 19 43	227 16 49	School-house Hill.	8213.7	3.91454
278 35 13	98 41 13	Kongscut ---- ---- ---- ----	12647.7	4.10201
21 27 07	201 25 59	School-house Hill.	6449.4	3.80952
319 38 44	139 43 22	Pine Hill ---- ---- ---- ----	14933.4	4.17416
15 27 39	195 25 23	Westfield.	17779.5	4.24992
296 50 27	116 56 52	Kongscut ---- ---- ---- ----	14999.3	4.17607
7 44 44	187 44 01	School-house Hill.	10990.1	4.04100
298 51 04	118 57 54	Kongscut ---- ---- ---- ----	16190.1	4.20925
3 16 40	183 16 20	School-house Hill.	11950.6	4.07739
303 17 23	123 24 18	Kongscut ---- ---- ---- ----	17259.6	4.23703
1 50 55	181 50 42	School-house Hill.	13597.5	4.13346
329 49 05	149 52 30	Taylor ---- ---- ---- ---- ----	14191.9	4.15204
1 51 23	181 51 10	School-house Hill.	13746.8	4.13820
299 54 26	120 06 16	Kongscut ---- ---- ---- ----	28455.7	4.45417
331 50 46	151 55 28	School-house Hill.	20786.9	4.31779
17 34 07	197 28 05	Sandford ---- ---- ---- ----	41831.1	4.62150
99 11 57	278 54 54	Ivy.	35805.5	4.55395
304 33 25	124 39 05	Kongscut ---- ---- ---- ----	14354.6	4.15699
13 56 46	193 55 19	School-house Hill.	12626.4	4.10128
379 38 42	199 38 14	Cornfield Point 2 ---- ---- ---- ----	2938.8	3.46817
106 51 49	286 50 45	Beacon Hill 3.	2359.2	3.37276
79 21 04	259 19 08	Cornfield Point 2 ---- ---- ---- ----	4169.5	3.62008
116 33 23	296 30 51	Beacon Hill 3.	5999.2	3.77809
296 12 51	116 19 46	Kongscut ---- ---- ---- ----	16063.5	4.20584
2 18 38	182 18 25	School-house Hill.	11224.4	4.05016
67 13 20	247 12 01	Cornfield Point 2 ---- ---- ---- ----	3022.3	3.48033
119 22 14	299 20 22	Beacon Hill 3.	4653.4	3.66777
104 24 29	284 21 22	Beacon Hill 2 ---- ---- ---- ----	6804.9	3.83282
140 25 24	320 23 44	Ferry 2.	5526.9	3.74248
231 31 49	51 32 44	Bog Hole Hill 2 ---- ---- ----	2486.8	3.39564
300 29 10	120 30 41	Lay's Hill 3.	3748.9	3.57390
146 37 01	326 36 24	Beacon Hill 2 ---- ---- ---- ----	2367.2	3.37424
201 13 13	21 14 03	Ferry 2.	4876.6	3.68812
94 29 50	274 26 42	Beacon Hill 2 ---- ---- ---- ----	6633.2	3.82172
131 03 50	311 02 09	Ferry 2.	4699.3	3.67203
356 43 14	176 43 19	Cornfield Point 2 ---- ---- ---- ----	2820.9	3.45039
120 20 52	300 20 21	Beacon Hill 2.	1273.2	3.10491
80 47 12	260 46 26	Cornfield Point 2 ---- ---- ---- ----	1665.2	3.22147
249 54 22	69 57 02	Lay's Hill 3.	6003.4	3.77840
306 16 06	126 17 37	Malicah ---- ---- ---- ----	3978.7	3.59974
38 18 35	218 17 41	Essex.	3071.1	3.48730

CONNECTICUT RIVER TO HOUSATONIC RIVER.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Sachem's Head.	41 16 58.584	1807.2	72 43 30.778	716.2
Hammonasset.	41 14 55.958	1726.2	72 32 40.428	941.1
Horton's Point, N. Y.	41 04 58.211	1795.7	72 26 53.615	1251.5
Mattituck Hills, N. Y.	41 00 08.464	261.1	72 34 29.752	695.3
Brown's Hill, N. Y.	41 09 11.289	348.3	72 17 36.460	850.2
Falkner's Island L. H. 1833–'82.	41 12 43.177	1331.9	72 39 14.453	336.6
Mount Carmel.	41 25 51.799	1598.0	72 53 25.637	595.3
Milford.	41 13 26.433	815.4	73 01 15.506	361.2
West Rock.	41 19 56.423	1740.6	72 57 42.615	990.9
Fort Wooster.	41 16 55.719	1718.8	72 53 35.181	818.6
Prindle.	41 16 05.116	157.8	72 59 32.630	759.5
Jones, New Haven County.	41 15 37.799	1166.0	72 58 25.794	600.4
Hickox.	41 23 12.432	383.5	73 00 13.529	314.4
New Haven L. H. 1833–'82.	41 14 56.398	1739.9	72 54 15.132	352.3
North Killingworth Congregational church. 1836–'82.	41 21 47.073	1452.2	72 33 58.071	1349.7
High Hill.	41 20 37.566	1158.9	72 37 41.954	975.4
Westbrook Congregational church. 1861–'82.	41 17 10.644	328.4	72 27 00.731	17.0
Gunn.	41 13 56.530	1743.9	73 04 57.965	1349.9
Milford Congregational church 1833–'84.	41 13 36.632	1130.0	73 03 33.027	769.2
West Rock 2. 1871.	41 19 56.416	1740.5	72 57 42.004	976.7
Rabbit Rock.	41 20 31.628	975.7	72 51 12.189	283.4
Hickox. 1839–'76.	41 23 12.750	393.3	73 00 13.748	319.5
Peck.	41 22 54.106	1669.2	73 03 30.473	708.1

CONNECTICUT RIVER TO HOUSATONIC RIVER.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
0 24 39.9	180 24 32.9	Friar's Head	34634.6	4.539505
86 56 00.5	266 35 13.4	Tashua.	44073.6	4.644178
131 56 00.6	311 48 35.3	Sugarloaf	21071.1	4.323688
104 05 23.6	283 58 14.7	Sachem's Head.	15603.9	4.193233
156 21 20.8	336 17 32.5	Hammonasset	20134.4	4.303939
194 24 43.7	14 27 08.1	Cornfield Point.	20514.1	4.312053
158 00 21.2	337 54 25.2	Sachem's Head	33618.3	4.526576
229 57 45.6	50 02 45.1	Horton's Point.	13906.5	4.143219
116 52 04.7	296 42 09.1	Hammonasset	23594.2	4.372806
146 54 05.5	326 50 22.6	Cornfield Point.	14400.7	4.158383
344 02 54.9	164 06 02.1	Mattituck Hills	24210.9	4.384011
13 08 00.9	193 05 05.4	Friar's Head.	27470.1	4.438860
57 57 32.9	237 43 17.0	Tashua	35583.2	4.551245
10 27 22.0	190 21 44.7	Ruland.	66181.0	4.820733
205 22 27.5	25 27 37.8	Mount Carmel	25458.5	4.405833
101 58 47.8	281 49 43.4	Tashua.	19652.6	4.293420
22 24 08.9	202 21 48.4	Milford	13011.2	4.114317
71 49 42.6	251 38 17.1	Tashua.	25449.8	4.405684
180 46 03.6	0 46 09.9	Mount Carmel	16539.4	4.218521
58 58 35.5	238 53 32.0	Milford.	12511.7	4.097317
199 43 20.2	19 44 32.8	West Rock	7580.8	3.879716
259 20 22.6	79 24 18.4	Fort Wooster.	8464.5	3.927601
187 10 21.7	7 10 50.2	West Rock	8041.4	3.905331
250 24 34.7	70 27 46.4	Fort Wooster.	7178.6	3.856038
321 24 25.7	141 28 48.8	For Wooster	14861.3	4.172056
4 33 56.5	184 33 15.6	Milford.	18135.1	4.258521
74 12 38.1	254 08 01.0	Milford	10175.4	4.007553
183 15 10.6	3 15 43.3	Mount Carmel.	20251.6	4.306460
351 53 15.2	171 54 06.4	Hammonasset	12810.6	4.107570
56 18 09.6	236 11 51.4	Sachem's Head.	16019.1	4.204639
326 19 13.6	146 22 32.6	Hammonasset	12660.0	4.102433
50 15 05.4	230 11 15.1	Sachem's Head.	10558.0	4.023580
64 17 13.5	244 09 09.7	Falkner's Island L. H.	18971.7	4.278106
131 20 28.4	311 15 52.8	North Killingworth church.	12920.0	4.111261
162 37 33.1	342 36 48.4	Bennet	5288.0	3.723290
222 20 28.4	42 25 15.6	West Rock.	15030.2	4.176964
147 52 02.1	327 50 21.4	Bennet	6685.3	3.825123
275 35 50.3	95 37 20.9	Milford.	3218.5	3.507656
22 27 39.1	202 25 18.2	Milford	13016.4	4.114492
208 29 37.4	28 32 26.9	Mount Carmel.	12477.4	4.096123
83 12 06.7	263 07 49.2	West Rock 2	9128.8	3.960415
162 35 04.6	342 33 36.4	Mount Carmel.	10352.5	4.015045
291 29 56.8	111 35 54.7	Rabbit Rock	13533.0	4.131393
4 32 49.7	184 32 08.9	Milford.	18144.5	4.258746
119 31 33.6	299 28 42.8	Riggs	6893.4	3.838434
262 48 37.9	82 50 48.0	Hickox 2.	4607.0	3.663419

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Hooper.	41 24 56.462	1741.8	73 00 03.974	92.3
Collins.	41 26 20.283	625.8	73 00 44.902	1042.4
West Rock Ridge.	41 25 07.751	239.1	72 57 18.832	437.3
East Rock 2. 1871.	41 19 42.429	1309.0	72 54 26.321	612.1
West Rock north.	41 22 58.882	1816.5	72 57 44.840	1041.9
Dead tree.	41 21 13.756	424.4	72 58 30.219	702.5
Yale College middle spire.	41 18 30.124	929.3	72 55 44.456	1034.2
New Haven, Saint Paul's Episcopal church, southwest spire.	41 18 13.743	424.0	72 55 13.855	322.2
Southwest Ledge L. H. 1875–'82.	41 14 04.140	127.7	72 54 45.082	1049.9
Branford Reef Beacon. 1881–'82.	41 13 16.783	517.8	72 48 20.682	481.9
Poplar 2. 1882.	41 16 30.470	940.0	72 50 22.648	527.1
Quarry, New Haven County.	41 15 26.373	813.6	72 43 59.374	1382.2
Boulder.	41 14 34.793	1073.4	72 42 21.457	499.7
Tuxis Island 2. 1882.	41 15 57.089	1761.2	72 36 06.351	147.8
Hammonasset 2. 1882.	41 14 55.841	1722.7	72 32 40.588	945.0
Highlands.	41 15 56.182	1733.2	72 38 57.528	1339.1
Murdock 2. 1882.	41 17 06.831	210.7	72 28 21.730	505.7
Duck Island 2. 1882.	41 15 23.912	737.7	72 28 33.262	774.3
Kelsey Westbrook.	41 16 27.005	833.1	72 25 28.458	662.3
Fort Wooster 3. 1882.	41 16 55.924	1725.3	72 53 35.121	817.3
Winchester Hill.	41 19 28.038	865.0	72 55 18.957	440.8
East Rock.	41 19 37.42	1154.4	72 54 17.44	405.6
Allen.	41 17 40.30	1243.2	72 58 23.88	555.6

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		Metres.	
88 01 36.1	267 56 28.7	Riggs ---- ---- ---- ----	10800.6	4.033448
4 03 36.0	184 03 29.5	Hickox 2.	3207.6	3.506178
352 52 06.4	172 52 27.0	Hickox 2 ---- ---- ---- ----	5830.5	3.765703
31 10 20.3	211 08 30.8	Peck.	7432.7	3.871145
255 53 27.6	75 56 01.9	Mount Carmel ---- ---- ---- ----	5582.9	3.746860
48 53 21.3	228 51 25.6	Hickox 2.	5394.0	3.731912
95 26 04.9	275 23 55.7	West Rock 2 ---- ---- ---- ----	4570.9	3.660003
187 02 55.5	7 03 35.6	Mount Carmel.	11481.9	4.060015
322 41 41.6	142 43 52.8	East Rock 2 ---- ---- ---- ----	7617.4	3.881806
296 25 34.3	116 29 53.7	Rabbit Rock.	10194.5	4.008364
219 29 35.4	39 32 56.8	Mount Carmel ---- ---- ---- ----	11119.7	4.046092
296 23 49.8	116 26 30.9	East Rock 2.	6332.1	3.801548
239 21 02.1	59 24 01.9	Rabbit Rock ---- ---- ---- ----	7358.2	3.866773
134 14 52.3	314 13 34.7	West Rock 2.	3815.9	3.581595
232 51 29.9	52 54 09.5	Rabbit Rock ---- ---- ---- ----	7048.6	3.848105
132 36 12.9	312 34 35.2	West Rock 2.	4680.4	3.670283
159 16 00.6	339 14 03.8	West Rock 2 ---- ---- ---- ----	11621.2	4.065252
82 44 44.2	262 40 26.9	Milford.	9167.2	3.962238
133 23 32.1	313 17 21.9	West Rock 2 ---- ---- ---- ----	17962.7	4.254371
91 00 57.4	270 52 26.8	Milford.	18050.2	4.256482
53 33 57.6	233 31 04.5	S. W. Ledge L. H., 1882---- ---- ----	7596.5	3.880615
334 34 05.3	154 35 25.7	Branford R. Beacon, 1881–'82.	6615.6	3.820570
56 43 11.3	236 40 19.0	Branford R. Beacon, 1881–'82. ---- ----	7280.7	3.862176
102 31 55.4	282 27 42.6	Poplar 2.	9138.1	3.960854
308 18 39.5	128 20 42.7	Falkner's Island L. H. ---- ---- ----	5552.1	3.744461
73 59 05.8	253 55 09.0	Branford R. Beacon, 1881.	8705.3	3.939785
36 13 50.4	216 11 46.4	Falkner's Island L. H. ---- ---- ----	7414.3	3.870070
73 49 28.9	253 45 21.5	Boulder.	9094.5	3.958781
65 59 31.7	245 55 12.1	Falkner's Island L. H. ---- ---- ----	10044.6	4.001934
111 32 42.6	291 30 26.9	Tuxis Island 2.	5149.4	3.711756
3 47 18.9	183 47 07.7	Falkner's Island L. H. ---- ---- ----	5967.1	3.775760
281 56 30.5	102 00 39.0	Hammonasset 2.	8970.6	3.952822
56 10 32.8	236 07 42.1	Hammonasset 2 ---- ---- ----	7255.0	3.860636
137 53 33.2	317 49 51.1	N. Killingworth church.	11658.8	4.066654
81 28 12.5	261 25 29.4	Hammonasset 2 ---- ---- ----	5823.0	3.765145
184 49 52.2	4 49 59.8	Murdock 2.	3186.3	3.503288
65 40 20.5	245 38 18.6	Duck Island 2 ---- ---- ---- ----	4721.6	3.674091
106 57 39.3	286 55 45.0	Murdock 2.	4215.5	3.624849
134 08 09.0	314 05 26.0	West Rock 2 ---- ---- ---- ----	7999.2	3.903047
166 56 58.1	346 56 24.3	East Rock 2.	5272.9	3.722048
104 45 26.4	284 43 51.9	West Rock 2 ---- ---- ---- ----	3439.8	3.536539
250 03 36.2	70 04 11.0	East Rock 2.	1302.1	3.114651
348 50 57	168 51 25	Fort Wooster ---- ---- ---- ----	5084.3	3.70623
97 01 24	276 59 09	West Rock.	4707.3	3.68190
281 32 39	101 35 49	Fort Wooster ---- ---- ---- ----	6857.3	3.83615
27 02 48	207 00 55	Milford.	8792.0	3.94409

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Pond Point.	41 12 41.24	1272.2	73 00 38.20	889.9
Milford Point.	41 10 42.67	1316.3	73 05 51.92	1210.2
Jeremy South.	41 15 39.47	1217.6	72 56 02.96	68.9
Jeremy North.	41 16 13.51	416.8	72 56 03.18	74.0
Oyster River Point.	41 14 02.20	67.9	72 58 33.11	771.1
Hillhouse.	41 19 40.61	1252.8	72 59 48.57	1129.6
Benham's house chimney.	41 15 07.91	244.0	72 58 54.40	1266.6
Brewster's factory, cupola.	41 18 09.46	291.8	72 54 38.72	900.9
Milford, old spire with gilt ball.	41 13 37.46	1155.6	73 03 25.97	604.9
North Milford spire.	41 16 42.20	1301.8	73 01 35.36	823.0
Woodbridge, round spire.	41 21 17.81	549.4	73 00 46.17	1073.3
Woodbridge, pointed spire.	41 21 14.63	451.3	73 00 48.72	1132.6
Charles Island poplar.	41 11 28.16	868.7	73 03 18.96	441.8
West Haven spire.	41 16 17.67	545.1	72 57 02.98	69.4
1833.				
Fair Haven spire.	41 18 35.20	1085.9	72 53 26.33	612.5
Hungry Hill.	41 18 49.90	1539.4	72 41 33.02	768.0
Moose Hill (New Haven County).	41 18 22.56	696.0	72 44 34.18	795.2
Hogshead Point.	41 16 10.60	327.0	72 38 15.26	355.2
Mulberry Point.	41 15 37.52	1157.4	72 40 55.47	1291.4
Great Hummock.	41 15 35.22	1086.5	72 30 43.34	1009.0
Long Hill (Middlesex County).	41 17 26.35	812.9	72 30 47.08	1095.4
Horsepond.	41 17 36.20	1116.7	72 35 20.92	486.8
Camp's Hill.	41 16 30.41	938.1	72 34 13.41	312.1

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
148 03 44	328 03 19	Milford	1642.9	3.21562
209 30 11	29 31 38	Jones.	6258.9	3.79650
37 10 39	217 09 50	Stratford Point	2862.8	3.45679
134 08 42	314 06 31	Stratford Hill.	6455.4	3.80992
89 08 10	269 06 36	Jones	3325.7	3.52188
163 42 13	343 41 07	West Rock.	8258.3	3.91689
71 39 26	251 37 52	Jones	3497.8	3.54380
161 24 54	341 23 48	West Rock.	7255.5	3.86067
49 24 37	229 23 15	Pond Point	3837.9	3.58409
73 45 08	253 43 21	Milford.	3939.9	3.59549
260 32 08	80 33 31	West Rock	2969.7	3.47271
300 19 13	120 23 20	Fort Wooster.	10066.1	4.00286
75 27 18	255 23 18	Gunn	8727.1	3.94187
190 37 23	10 38 10	West Rock.	9055.7	3.95692
48 30 00	228 27 30	Jones	7057.8	3.84867
127 40 04	307 38 02	West Rock.	5402.1	3.73256
230 00 13	50 02 47	Prindle	7090.0	3.85065
276 23 04	96 24 30	Milford.	3057.5	3.48537
42 43 24	222 41 10	Gunn	6954.7	3.84228
89 26 18	269 23 20	Bennet.	6294.8	3.79898
192 06 28	12 06 50	Hickox	3616.3	3.55826
335 55 38	155 56 16	Hillhouse.	3284.1	3.51641
192 40 51	12 41 14	Hickox	3724.9	3.57111
334 15 08	154 15 48	Hillhouse.	3220.0	3.50786
55 11 22	235 08 53	Stratford Point	6450.4	3.80959
158 01 44	337 59 54	Bennet.	10378.9	4.01615
57 28 01	237 27 06	Jones	2286.8	3.35922
172 13 19	352 12 53	West Rock.	6811.0	3.83321
33 55 31	213 53 48	Jeremy South	6532.7	3.81509
51 53 07	231 49 50	Jones.	8860.5	3.94746
238 15 17	58 17 50	High Hill	6317.3	3.80053
300 09 36	120 15 27	Hammonasset.	14342.3	4.15662
258 40 10	78 42 10	Hungry Hill	4297.8	3.63325
330 20 10	150 20 52	Sachem's Head.	2981.3	3.47440
185 22 17	5 22 39	High Hill	8272.0	3.91761
286 25 31	106 29 12	Hammonasset.	8127.6	3.90996
205 55 12	25 57 20	High Hill	10293.2	4.01255
276 18 05	96 23 32	Hammonasset.	11596.3	4.06432
133 48 05	313 43 28	High Hill	13484.7	4.12984
95 57 54	275 52 56	Hogshead Point.	10576.0	4.02432
29 38 16	209 37 01	Hammonasset	5337.0	3.72730
175 49 49	355 49 34	Williams.	7194.5	3.85700
272 42 22	92 45 23	Long Hill	6379.1	3.80476
322 54 26	142 56 12	Hammonasset.	6196.1	3.79212
147 33 10	327 30 52	High Hill	9037.3	3.95604
289 10 34	109 12 53	Great Hummock.	5177.7	3.71414

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Graves.	41 17 52.84	1630.0	72 36 51.65	1201.7
Murdock.	41 17 10.50	323.9	72 28 20.94	487.3
Mill Rock.	41 16 48.22	1487.5	72 51 47.65	1108.8
Setauket.	41 19 36.49	1125.7	72 46 32.11	746.8
Indian Neck.	41 15 23.82	734.8	72 49 19.76	459.9
Plant's Hill.	41 16 39.10	1206.2	72 50 29.84	694.5
Hemmingway.	41 18 58.19	1795.1	72 52 12.37	287.7
Hoadley's Neck.	41 15 27.53	849.3	72 44 10.04	233.7
Tuxis Island.	41 15 57.89	1785.8	72 36 08.32	193.7
Barker.	41 15 15.84	488.6	72 48 34.22	796.6
Page.	41 19 22.92	707.1	72 48 11.92	277.2
Great Rock.	41 20 31.54	973.0	72 51 11.30	262.7
Griswold.	41 17 30.24	932.9	72 39 36.26	843.7
Stony Creek.	41 16 23.30	718.8	72 45 21.29	495.5
Cow Hill.	41 17 44.40	1369.6	72 32 29.65	689.9
Spink's Hill.	41 16 37.70	1163.0	72 50 58.79	1368.3
Morgan's Point.	41 14 32.70	1008.8	72 53 39.53	920.5
Duck Island.	41 15 23.67	730.2	72 28 33.14	771.5
Bartlett.	41 14 54.10	1668.9	72 42 44.85	1044.2
East Haven spire.	41 16 41.82	1290.1	72 52 19.72	459.0
Madison church spire. 1838.	41 16 44.80	1382.0	72 36 08.35	194.3
Madison Congregational church spire. 1882.	41 16 47.90	1477.6	72 36 12.79	297.6
Dragon brick church spire.	41 18 35.18	1085.2	72 53 26.31	612.0

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
105 04 33	285 01 27	Hungry Hill	6778.0	3.83110
167 02 15	347 01 42	High Hill.	5214.8	3.71724
55 31 49	235 28 58	Hammonasset	7328.6	3.86502
116 08 06	296 01 55	High Hill.	14529.1	4.16224
95 17 07	275 15 56	Fort Wooster	2512.8	3.40016
125 08 36	305 04 42	West Rock.	10094.6	4.00409
261 15 37	81 21 27	High Hill	12470.7	4.09589
319 05 27	139 07 27	Sachem's Head.	6444.1	3.80916
230 17 26	50 20 34	Moose Hill	8635.6	3.93629
250 10 26	70 14 16	Sachem's Head.	8633.0	3.93616
248 52 37	68 56 31	Moose Hill	8869.9	3.94792
266 26 05	86 30 41	Sachem's Head.	9771.5	3.98996
27 01 37	207 00 42	Fort Wooster	4240.9	3.62746
103 11 43	283 08 05	West Rock.	7887.7	3.89695
104 03 28	283 59 17	Plant's Hill	9112.1	3.95962
174 03 55	354 03 39	Moose Hill.	5428.8	3.73470
97 34 09	277 32 45	Hogshead Point	2980.4	3.47428
165 50 25	345 49 23	High Hill.	8898.6	3.94932
133 40 24	313 39 08	Plant's Hill	3720.5	3.57060
245 48 12	65 51 32	Sachem's Head.	7741.9	3.88885
304 13 15	124 16 21	Sachem's Head	7912.4	3.89831
32 25 34	212 24 03	Plant's Hill.	5986.6	3.77718
26 42 01	206 40 26	Fort Wooster	7452.0	3.87227
68 55 14	248 53 11	East Rock.	4639.0	3.66642
204 41 40	24 42 55	High Hill	6361.2	3.80354
296 08 44	116 13 18	Hammonasset.	10785.7	4.03285
196 35 13	16 35 44	Moose Hill	3838.9	3.58421
247 03 06	67 04 19	Sachem's Head.	2792.7	3.44603
328 09 20	148 10 30	Great Hummock	4690.4	3.67121
2 45 55	182 45 48	Hammonasset.	5202.1	3.71618
98 41 48	278 40 05	Fort Wooster	3681.6	3.56604
266 19 16	86 19 35	Plant's Hill.	674.9	2.82927
79 08 40	259 03 39	Milford	10814.3	4.03400
181 18 49	1 18 52	Fort Wooster.	4413.1	3.64474
81 34 44	261 32 01	Hammonasset	5820.6	3.76497
161 38 54	341 37 11	Williams.	11548.6	4.06253
164 26 52	344 26 22	Sachem's Head	3986.0	3.60054
269 42 42	89 49 20	Hammonasset.	14073.1	4.14839
128 39 44	308 36 11	West Rock	9615.7	3.98298
153 11 37	333 10 19	East Rock.	6070.3	3.78321
70 21 18	250 19 54	Hogshead Point	3136.6	3.49646
163 08 21	343 07 19	High Hill.	7503.3	3.87525
304 57 59	125 00 19	Hammonasset 2	6028.9	3.78024
29 16 42	209 14 42	Falkner's Island L. H.	8653.7	3.93720
247 34 22	67 35 11	Hemmingway	1860.4	3.26961
3 51 00	183 50 54	Fort Wooster.	3075.4	3.48790

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
North Guilford church spire.	41 22 05.84	180.2	72 43 39.44	916.6
Branford Reef Beacon. 1833.	41 13 16.73	516.1	72 48 20.58	479.4
Branford church spire. 1838.	41 16 51.86	1599.8	72 48 41.63	968.7
Clinton church spire. 1838.	41 16 42.68	1316.6	72 31 24.50	570.2
Huddenston.	41 26 57.06	1760.3	72 58 24.78	575.2
Sandford. 1839.	41 28 07.64	235.7	72 57 13.78	319.8
Mount Ephraim.	41 27 47.45	1463.8	72 54 56.64	1314.4
No Name.	41 26 41.35	1275.6	72 57 30.62	710.8
Slate Hill.	41 22 28.22	870.6	72 58 52.19	1212.9
Lebanon.	41 26 26.56	819.4	72 59 38.96	904.4
Skagerat.	41 24 46.21	1425.6	73 03 08.84	205.3
Summerville.	41 20 32.78	1011.3	73 03 28.56	664.0
Newton.	41 25 51.86	1599.9	73 02 04.58	106.4
Dickerman.	41 25 06.94	214.1	72 55 42.34	983.2
Mount Prospect.	41 28 22.70	700.3	72 58 16.34	379.2
Prospect church spire.	41 30 07.69	237.2	72 58 41.88	971.4
Wallingford church spire.	41 27 15.75	485.9	72 49 08.42	195.4
Bethany church spire.	41 25 30.92	953.9	72 59 47.33	1099.0
Cheshire church spire.	41 29 52.78	1628.3	72 54 12.18	282.5
Paddock.	41 16 25.92	799.6	72 34 13.68	318.4
Hammonasset Hotel chimney.	41 16 17.35	535.3	72 35 10.39	241.8
Kelsey Clinton.	41 15 24.44	754.0	72 30 27.65	643.8
Clinton church spire. 1882.	41 16 39.89	1230.6	72 31 38.74	901.6

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
334 03 24	154 04 48	Hungry Hill ---- ---- ---- ----	6721. 4	3. 82746
10 28 38	190 28 02	Moose Hill.	7004. 5	3. 84538
107 32 29	287 28 59	Morgan's Point ---- ---- ---- ----	7790. 2	3. 89155
132 42 44	312 39 17	Fort Wooster.	9963. 5	3. 99841
244 03 23	64 06 06	Moose Hill ---- ---- ---- ----	6401. 2	3. 80626
268 19 44	88 23 09	Sachem's Head.	7237. 2	3. 85957
28 13 58	208 13 08	Hammonasset ---- ---- ---- ----	3736. 8	3. 57250
106 43 31	286 40 55	Horsepond.	5743. 9	3. 75921
286 08 20	106 11 38	Mount Carmel ---- ---- ---- ----	7230. 7	3. 85918
335 34 21	155 35 05	West Rock Ridge.	3703. 1	3. 56856
308 20 05	128 22 36	Mount Carmel ---- ---- ---- ----	6753. 4	3. 82952
37 07 22	217 06 35	Huddenston.	2730. 7	3. 43627
329 21 52	149 22 52	Mount Carmel ---- ---- ---- ----	4146. 2	3. 61765
101 05 09	281 03 38	Sandford.	3243. 2	3. 51097
240 16 38	60 18 20	Mount Ephraim ---- ---- ----	4114. 5	3. 61432
285 01 21	105 04 03	Mount Carmel.	5889. 2	3. 77006
125 56 43	305 55 49	Hickox 2 ---- ---- ---- ----	2304. 7	3. 36935
203 46 22	23 47 24	West Rock Ridge.	5378. 2	3. 73064
306 45 22	126 46 55	West Rock Ridge ---- ---- ----	4061. 6	3. 60870
7 41 59	187 41 36	Hickox 2.	6033. 4	3. 78056
8 16 08	188 15 54	Peck ---- ---- ---- ---- ----	3494. 6	3. 54340
89 27 54	269 24 49	Riggs.	6501. 3	3. 81300
179 25 03	359 25 02	Peck ---- ---- ---- ---- ----	4359. 8	3. 63947
222 31 15	42 33 24	Hickox 2.	6697. 5	3. 82591
43 12 06	223 08 50	Great Hill East ---- ---- ----	10076. 3	4. 00330
75 22 55	255 19 07	Riggs.	8260. 6	3. 91701
192 05 17	12 05 47	Mount Ephraim ---- ---- ----	5064. 3	3. 70452
246 25 36	66 27 07	Mount Carmel.	3462. 8	3. 53943
287 44 46	107 45 27	Sandford ---- ---- ---- ----	1524. 1	3. 18300
4 14 26	184 14 20	Huddenston.	2649. 5	3. 42316
37 18 52	217 13 21	Great Hill East ---- ---- ----	19151. 4	4. 28220
51 52 07	231 46 05	Riggs.	16146. 9	4. 20809
66 34 26	246 31 36	Mount Carmel ---- ---- ---- ----	6508. 5	3. 81348
98 07 58	278 02 37	Sandford.	11377. 3	4. 05604
19 58 38	199 58 27	Hooper ---- ---- ---- ----	1130. 8	3. 05340
138 43 57	318 43 19	Collins.	2026. 3	3. 30670
351 43 49	171 44 20	Mount Carmel ---- ---- ---- ----	7512. 2	3. 87577
52 25 40	232 23 40	Sandford.	5317. 2	3. 72568
322 02 35	142 03 36	Hammonasset 2 ---- ---- ----	3524. 0	3. 54704
45 34 24	225 31 06	Falkner's Island L. H.	9811. 6	3. 99173
305 46 45	125 48 24	Hammonasset 2 ---- ---- ----	4299. 2	3. 63339
40 43 28	220 40 47	Falkner's Island L. H.	8715. 1	3. 94027
74 06 00	254 04 32	Hammonasset 2 ---- ---- ----	3218. 1	3. 50760
222 50 54	42 52 17	Murdock 2.	4308. 6	3. 63436
324 34 57	144 35 44	Kelsey Clinton ---- ---- ---- ----	2855. 7	3. 45571
24 09 42	204 09 01	Hammonasset 2.	3518. 2	3. 54632

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
West Rock. 1882.	41 15 12.75	393.4	72 32 01.71	39.8
Horse, cupola of house.	41 14 39.86	1229.6	72 45 31.03	722.6
Lewis' Grove.	41 16 16.03	494.5	72 29 08.62	200.6
Menunketesuck.	41 15 42.73	1318.2	72 27 48.99	1140.4
Fish-house.	41 15 49.62	1530.7	72 27 53.71	1250.3
Hen and Chickens Beacon. 1882.	41 15 12.16	375.2	72 24 18.33	426.7
North Sheffield College, south chimney, lightning rod.	41 18 45.96	1417.8	72 55 31.67	736.7
Yale observatory center peg.	41 19 28.48	878.6	72 55 19.16	445.6
Yale observatory, east dome, apex.	41 19 28.48	878.6	72 55 18.06	420.0
North Sheffield College, plumb line over smaller observatory in college grounds.	41 18 46.29	1428.0	72 55 30.89	718.5
North Sheffield College, larger observatory in college grounds.	41 18 47.00	1449.9	72 55 30.89	718.5
St. Francis' Orphan Asylum cupola.	41 19 43.78	1350.6	72 55 07.62	177.2
Westbrook church spire. 1836.	41 17 10.65	328.6	72 27 00.72	16.7
Walnut, flag in tree.	41 11 28.40	876.1	73 03 18.94	441.5
Burns' Point.	41 12 37.34	1151.9	73 03 01.45	33.8
Miles' Fish Works, chimney.	41 12 07.60	234.5	73 02 18.20	424.0
Milford, Episcopal church spire.	41 13 27.23	840.0	73 03 27.73	645.9
Thompson's house, south chimney. 1881–'84.	41 12 39.32	1213.0	73 00 37.73	879.0
Post.	41 13 22.33	688.9	72 59 40.60	945.7
Clark's Point.	41 14 00.32	9.9	72 58 43.15	1005.0
Pritchard's house flag-staff.	41 11 28.30	873.1	73 03 19.65	457.9
Clam Island, white house, chimney near south gable.	41 14 49.33	1521.8	72 48 58.44	1360.8
Town Post.	41 15 27.60	851.4	72 43 54.11	1259.7

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
191 14 44	11 14 59	Clinton church spire, 1882	2740.9	3.43789
260 38 02	80 39 04	Kelsey Clinton.	2219.3	3.34622
57 02 41	237 00 49	Branford R. Beacon, 1881	4709.3	3.67296
116 42 44	296 39 32	Poplar 2.	7597.7	3.88068
332 53 31	152 53 54	Duck Island 2	1806.3	3.25680
49 08 47	229 07 55	Kelsey Clinton.	2432.2	3.38600
60 36 33	240 36 04	Duck Island 2	1182.8	3.07291
119 00 31	298 59 39	Lewis' Grove.	2119.1	3.32615
332 38 30	152 38 33	Menunketesuck	239.3	2.37888
49 15 31	229 15 05	Duck Island 2.	1215.1	3.08460
144 44 41	324 43 55	Kelsey Westbrook	2827.6	3.45142
237 42 36	57 43 18	Cornfield Point 2.	1751.4	3.24338
125 39 21	305 37 55	West Rock 2	3729.8	3.57169
221 05 54	41 06 37	East Rock 2.	2312.0	3.36398
250 41 45	70 42 20	East Rock 2	1301.8	3.11454
341 38 41	161 38 41	Winchester Hill.	14.5	1.15994
56 33 54	236 33 53	Winchester Hill	25.0	1.39721
89 55 20	269 55 19	Yale observatory, center peg.	25.4	1.40447
60 50 16	240 50 15	N. Sheffield College, s. c. l. r.	20.8	1.31758
220 55 24	40 56 07	East Rock 2.	2292.4	3.36029
0	180	Plumb line over smaller obs'y.	22.0	1.34310
272 28 54	92 29 21	East Rock 2	961.3	2.98288
28 29 36	208 29 29	Winchester Hill.	552.6	2.74242
218 19 01	138 25 13	Brown's Hill	19784.7	4.29633
62 18 41	242 14 57	Hammonasset.	8932.6	3.95098
115 15 15	295 07 32	Tashua	18079.2	4.25718
218 17 29	38 18 50	Milford.	4639.9	3.66651
238 27 22	58 28 32	Milford	2895.3	3.46170
10 50 54	190 50 42	Walnut.	2165.4	3.33553
110 07 08	289 58 44	Tashua	18919.5	4.27691
210 58 54	30 59 35	Milford.	2836.8	3.45283
270 26 45	90 28 12	Milford	3079.6	3.48850
338 18 23	158 18 40	Burns' Point.	1656.2	3.21910
148 48 22	328 47 57	Milford	1698.8	3.23014
244 34 43	64 38 55	New Haven L. H.	9863.2	3.99402
45 05 40	225 05 02	Thompson's house chimney	1879.4	3.27401
93 16 41	273 15 38	Milford.	2214.3	3.34524
46 53 55	226 52 40	Thompson's house chimney	3655.9	3.56299
73 35 54	253 34 14	Milford.	3699.3	3.56812
175 29 56	355 29 47	Milford, Congregational church spire	3971.1	3.59891
218 25 34	38 26 56	Milford.	4652.5	3.66769
342 52 40	162 53 05	Branford R. Beacon, 1881	2987.3	3.47528
80 14 03	260 10 14	S. W. Ledge L. H.	8191.6	3.91337
307 03 10	127 04 11	Boulder	2703.4	3.43191
72 43 20	252 43 17	Quarry.	128.2	2.10790

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Hamden Methodist church.	41 21 11.38	351.1	72 55 53.14	1235.3
C.	41 16 14.33	442.1	72 54 21.20	493.4
New Haven South church.	41 17 53.48	1649.9	72 55 52.88	1230.3
Forbes.	41 17 47.40	1462.3	72 54 07.40	172.2
Fort Wooster 2. 1875.	41 16 55.68	1717.7	72 53 35.42	824.3
Oyster Point.	41 16 58.47	1803.7	72 55 48.98	1139.8
Baldwin's cupola.	41 17 42.64	1315.4	72 53 42.07	978.8
Fresenius' brewery, cupola.	41 17 56.34	1738.0	72 56 36.16	841.3
Long Hill (New Haven County).	41 24 08.31	256.4	72 53 09.57	222.3
Rogers, Smith & Co.'s cupola (on site of old "Brewster's factory cupola").	41 18 09.46	291.8	72 54 38.76	901.8
New Haven, St. Patrick's church.	41 18 30.72	947.7	72 54 42.41	986.6
New Haven, Grace church.	41 18 25.50	786.6	72 53 57.08	1327.9
New Haven, First Congregational church.	41 18 34.78	1072.9	72 53 38.15	887.6
New Haven, Baptist church.	41 18 33.50	1033.4	72 53 23.82	554.1
New Haven, school-house cupola.	41 18 35.19	1085.6	72 53 26.32	612.3
Lancraft's cupola.	41 18 05.15	158.9	72 53 17.68	411.4
Bigelow's house, chimney.	41 18 09.63	297.1	72 54 04.21	97.9
Car-shop chimney.	41 17 41.53	1281.1	72 55 37.48	872.1
New Haven Long Wharf L. H. 1873.	41 17 33.82	1043.3	72 54 56.49	1314.5
Sargent's cupola.	41 18 03.73	115.1	72 54 47.03	1094.4
Water.	41 17 20.00	617.0	72 55 40.34	938.6
Bridge.	41 17 33.28	1026.6	72 55 59.19	1377.3
Telegraph.	41 17 09.92	306.0	72 55 52.59	1223.8

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
47 35 47	227 34 35	West Rock 2	3428.3	3.53508
323 39 01	143 39 58	East Rock 2.	3406.4	3.53229
356 38 10	176 38 14	New Haven L. H.	2408.4	3.38173
161 36 27	341 35 52	New Haven St. Paul's Epis. church.	3882.2	3.58908
210 54 59	30 55 56	East Rock 2	3918.1	3.59308
146 13 12	326 12 00	West Rock 2.	4563.4	3.65929
172 55 55	352 55 43	East Rock 2	3575.9	3.55338
94 22 37	274 21 27	New Haven South church.	2461.4	3.39118
119 09 23	299 07 52	New Haven South church	3662.3	3.56375
167 02 37	347 02 03	East Rock 2.	5279.1	3.72256
176 56 18	356 56 15	New Haven South church	1699.6	3.23034
237 25 27	57 26 34	Forbes.	2804.7	3.44789
96 16 45	276 15 19	New Haven South church	3061.8	3.48598
164 26 26	344 25 57	East Rock 2.	3836.0	3.58388
222 41 19	42 42 45	East Rock 2	4453.5	3.64870
157 32 45	337 32 02	West Rock 2.	4008.5	3.60298
337 47 20	157 48 38	Rabbit Rock	7219.7	3.85852
71 30 34	251 27 32	West Rock North.	6744.2	3.82893
127 45 48	307 43 47	West Rock 2	5390.1	3.73160
185 45 28	5 45 36	East Rock 2.	2882.7	3.45980
328 37 53	148 38 16	Forbes	1564.9	3.19449
54 59 15	234 58 29	New Haven South church.	2001.9	3.30145
69 52 32	249 51 16	New Haven South church	2869.5	3.45780
164 00 52	344 00 33	East Rock 2.	2468.9	3.39251
67 53 27	247 51 58	New Haven South church	3383.5	3.52937
151 46 34	331 46 02	East Rock 2.	2368.8	3.37452
70 24 49	250 23 11	New Haven South church	3681.0	3.56596
113 05 47	293 02 57	West Rock 2.	6526.6	3.81469
69 20 19	249 18 42	New Haven South church	3644.3	3.56162
112 52 28	292 49 39	West Rock 2.	6452.8	3.80975
84 19 03	264 17 21	New Haven South church	3628.7	3.55975
151 59 40	331 58 55	East Rock 2.	3399.1	3.53137
78 51 48	258 50 36	New Haven South church	2576.8	3.41108
169 49 17	349 49 02	East Rock 2.	2908.8	3.46371
203 55 23	23 56 10	East Rock 2	4080.6	3.61072
265 03 09	85 04 08	Forbes.	2103.5	3.32295
190 01 40	10 02 00	East Rock 2	4029.4	3.60524
138 49 30	318 47 41	West Rock 2.	5846.0	3.76686
188 59 20	8 59 34	East Rock 2	3082.8	3.48894
130 31 13	310 29 18	West Rock 2.	5352.3	3.72854
248 38 06	68 39 07	Forbes	2321.9	3.36584
16 51 17	196 51 11	Oyster Point.	694.0	2.84134
151 34 10	331 33 02	West Rock 2	5021.7	3.70085
208 27 31	28 28 32	East Rock 2.	4532.2	3.65631
153 39 11	333 37 59	West Rock 2	5732.4	3.75834
203 05 36	23 06 33	East Rock 2.	5115.2	3.70886

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Stations.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Canal Dock.	41 17 38.30	1181.5	72 54 52.73	1226.9
New Haven Custom House Square, flag-staff.	41 18 02.82	87.0	72 55 26.63	619.5
Dike.	41 17 01.99	61.4	72 56 16.54	384.9
North Watch House.	41 16 44.40	1369.7	72 55 09.49	220.8
Sandy Point.	41 16 04.16	128.3	72 55 35.10	817.0
North.	41 17 35.88	1106.8	72 54 15.85	368.8
Crane's Bar.	41 17 06.14	189.4	72 54 13.95	324.6
East.	41 16 58.77	1813.0	72 53 58.50	1361.4
Fort Hale 2. 1874.	41 16 14.79	456.3	72 54 18.57	432.3
Ives's cupola.	41 18 31.69	977.6	72 52 52.00	1209.7
Grove.	41 19 02.97	91.6	72 52 57.23	1331.2
Pine street.	41 18 47.78	1474.0	72 53 16.56	385.2
Shell Heap.	41 18 43.58	1344.5	72 52 58.94	1371.0
Peck street.	41 19 02.44	75.3	72 53 19.01	442.2
North Quinnipiac.	41 19 28.71	885.7	72 53 20.77	483.1
Telegraph rod.	41 18 56.81	1752.6	72 53 14.72	342.4
Slaughter-house, east cupola.	41 19 17.26	532.5	72 53 33.27	773.8
Fair Haven, Second Congregational church.	41 18 27.90	860.7	72 53 08.81	205.0
Wire Works.	41 17 56.08	1730.1	72 53 43.65	1015.5
Townsend's cupola.	41 16 34.20	1055.1	72 53 45.27	1053.6
Peak on house near wharf.	41 16 35.91	1107.8	72 54 14.09	327.9
Red and white.	41 17 07.05	217.5	72 53 49.07	1141.8
White house, cupola.	41 17 24.46	754.6	72 54 10.08	234.5

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
189 06 37	9 06 54	East Rock 2	3878.3	3.58864
137 16 27	317 14 35	West Rock 2.	5801.5	3.76354
204 31 48	24 32 28	East Rock 2	3378.2	3.52868
138 04 27	318 02 58	West Rock 2.	4711.3	3.67314
199 06 40	19 06 55	New Haven, South church	1681.4	3.22567
279 35 39	99 35 57	Oyster Point.	650.5	2.81326
154 39 01	334 38 32	New Haven South, church	2358.2	3.37258
216 37 10	36 37 51	Forbes.	2421.8	3.38414
173 00 26	353 00 14	New Haven, South church	3397.9	3.53121
212 38 35	32 39 33	Forbes.	3783.0	3.57784
33 06 08	213 05 16	Sandy Point	3377.6	3.52862
103 31 51	283 30 47	New Haven, South church.	2321.9	3.36585
122 24 10	302 23 05	New Haven, South church	2726.3	3.43557
44 39 20	224 38 27	Sandy Point.	2687.6	3.42937
122 23 55	302 22 40	New Haven, South church	3151.7	3.49854
53 10 00	233 08 56	Sandy Point.	2809.2	3.44858
144 13 41	324 12 39	New Haven, South church	3753.0	3.57438
79 34 28	259 33 38	Sandy Point.	1810.9	3.25790
37 35 54	217 35 21	Baldwin's cupola	1909.3	3.28087
95 05 19	275 04 48	New Haven, First Congregational church.	1077.6	3.03247
352 49 03	172 49 07	Ives's cupola	972.8	2.98801
47 35 01	227 34 34	New Haven, First Congregational church.	1289.2	3.11031
310 59 43	130 59 59	Ives's cupola	756.8	2.87897
223 48 11	43 48 24	Grove.	649.4	2.81251
183 47 32	3 47 33	Grove	599.4	2.77775
107 31 48	287 31 36	Pine street.	429.9	2.63332
268 08 20	88 08 34	Grove	506.8	2.70485
321 14 38	141 14 51	Shell Heap.	745.9	2.87269
325 24 39	145 24 54	Grove	964.6	2.98435
357 06 03	177 06 04	Peck street.	811.6	2.90934
244 58 08	64 58 19	Grove	448.9	2.65217
318 01 51	138 02 01	Shell Heap.	549.0	2.73958
219 27 11	39 27 19	North Quinnipiac	457.4	2.66032
297 44 28	117 44 52	Grove.	947.2	2.97643
167 26 36	347 26 29	Peck street	1091.8	3.03814
205 22 38	25 22 44	Shell Heap.	535.7	2.72889
163 10 18	343 09 50	East Rock 2	3427.8	3.53502
88 29 02	268 27 37	New Haven, South church.	3007.9	3.47827
70 05 03	250 03 50	Sandy Point	2719.3	3.43445
129 29 18	309 27 54	New Haven, South church.	3847.2	3.58514
62 33 13	242 32 19	Sandy Point	2124.7	3.32730
136 09 37	316 08 32	New Haven, South church.	3318.3	3.52091
40 40 46	220 40 40	East	337.1	2.52772
87 14 11	267 13 55	Crane's Bar.	579.7	2.76321
38 37 23	218 36 27	Sandy Point	3170.5	3.50113
110 31 48	290 30 40	New Haven, South church.	2554.0	3.40722

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Mitchell's cupola, s. w. corner.	41 16 26.27	810.4	72 53 47.21	1098.8
Chemical Works, ventilator.	41 16 07.90	243.7	72 54 07.34	170.8
Pond Rock.	41 17 40.04	1235.2	72 51 24.46	569.1
South Pond Rock.	41 17 05.89	181.7	72 51 49.89	1160.9
North Pond Rock.	41 19 00.52	16.0	72 50 17.48	406.6
High Rock.	41 24 18.25	563.0	72 56 07.91	183.7
Tulip tree.	41 21 47.87	1476.8	72 54 00.68	15.8
Widow Dickerman.	41 23 32.76	1010.6	72 53 07.77	180.5
Centerville church.	41 23 01.59	49.0	72 54 11.50	267.2
Chestnut 1. 1875.	41 21 56.86	1754.2	72 57 05.62	130.6
Case.	41 22 31.63	975.8	72 53 32.34	751.5
Montowese church.	41 20 55.49	1711.9	72 51 45.80	1064.7
North Hill.	41 22 36.82	1135.9	72 49 18.43	428.3
Mansfield.	41 21 52.39	1616.3	72 50 20.97	487.4
Pinnacle.	41 18 58.65	1809.3	72 51 00.62	14.4
Thompson.	41 19 42.10	1298.8	72 49 58.20	1353.5
Chestnut 2. 1875.	41 23 12.86	396.8	72 55 28.34	658.5
East Haven flag-staff. 1875.	41 16 32.08	989.6	72 52 04.15	96.6
North Haven church spire.	41 23 12.97	400.1	72 51 42.66	991.2
Pine.	41 21 59.66	1840.5	72 58 25.68	596.8
West Rock North 2. 1875.	41 23 21.94	676.9	72 57 34.93	811.5
Bill Hill.	41 20 11.29	348.3	72 59 08.35	194.2
Sperry.	41 21 06.84	211.0	72 59 14.60	339.4

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
74 48 45	254 47 34	Sandy Point	2602.1	3.41533
132 37 37	312 36 14	New Haven South church.	3973.7	3.59919
86 46 42	266 45 44	Sandy Point	2046.0	3.31091
142 59 34	322 58 24	New Haven South church.	4079.5	3.61061
93 49 21	273 46 24	New Haven South church	6259.1	3.79651
183 05 08	3 05 16	Rabbit Rock.	5301.0	3.72436
104 34 40	284 32 00	New Haven South church	5841.6	3.76653
187 51 47	7 52 12	Rabbit Rock.	6407.2	3.80667
75 11 05	255 07 24	New Haven South church	8072.0	3.90698
155 38 56	335 38 20	Rabbit Rock.	3085.4	3.48931
315 27 50	135 31 05	Rabbit Rock	9803.2	3.99137
232 32 23	52 34 10	Mount Carmel.	4746.7	3.67639
300 58 02	120 59 53	Rabbit Rock	4568.6	3.65978
186 10 13	6 10 36	Mount Carmel.	7569.2	3.87905
334 18 50	154 20 06	Rabbit Rock	6200.0	3.79239
80 48 13	260 45 10	West Rock North.	6521.7	3.81436
317 58 12	138 00 10	Rabbit Rock	6226.6	3.79425
191 27 43	11 28 13	Mount Carmel.	5358.0	3.72900
318 13 14	138 14 59	East Rock 2	5560.1	3.74508
12 49 42	192 49 18	West Rock 2.	3810.7	3.58100
318 38 24	138 39 56	Rabbit Rock	4931.3	3.69296
181 26 38	1 26 42	Mount Carmel.	6177.5	3.79081
313 17 18	133 17 40	Rabbit Rock	1073.5	3.03081
165 46 15	345 45 09	Mount Carmel.	9430.6	3.97454
34 24 37	214 23 22	Rabbit Rock	4680.3	3.67028
136 21 08	316 18 25	Mount Carmel.	8315.9	3.91991
25 32 39	205 32 05	Rabbit Rock	2761.2	3.44110
101 17 17	281 12 23	West Rock North.	10517.7	4.02192
174 38 19	354 38 12	Rabbit Rock	2880.8	3.45956
266 42 28	86 42 57	North Pond Rock.	1004.9	3.00219
47 17 11	227 16 30	Pinnacle	1975.7	3.29572
131 36 49	311 36 00	Rabbit Rock.	2301.2	3.36195
309 51 14	129 54 03	Rabbit Rock	7757.8	3.88974
82 16 12	262 14 42	West Rock North.	3200.7	3.50525
108 55 34	288 54 34	Fort Wooster 2	2245.7	3.35135
189 17 00	9 17 34	Rabbit Rock.	7488.6	3.87440
351 54 07	171 54 27	Rabbit Rock	5027.4	3.70134
87 04 37	267 00 37	West Rock North.	8426.6	3.92565
307 14 29	127 17 07	East Rock 2	6992.0	3.84460
345 02 40	165 03 09	West Rock 2.	3935.2	3.59497
327 03 47	147 05 51	East Rock 2	8067.0	3.90671
1 29 10	181 29 05	West Rock 2.	6342.2	3.80224
204 41 49	24 42 14	Dead tree	2121.4	3.32662
282 51 35	102 52 32	West Rock 2.	2059.5	3.31376
258 17 59	78 18 28	Dead tree	1053.5	3.02263
355 09 13	175 09 17	Bill Hill.	1719.8	3.23549

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Doolittle.	41 22 25.18	776.8	72 58 48.29	1122.2
House chimney.	41 20 49.21	1518.1	72 58 55.31	1285.8
Hillside.	41 22 52.58	1622.1	72 57 57.35	1332.6
Pond Lily Paper Mill, chimney.	41 20 06.59	203.3	72 58 35.00	813.9
Barn cupola, (New Haven County).	41 20 26.80	826.8	72 58 42.77	994.4
Bethany South.	41 23 34.15	1053.5	72 58 03.90	90.6
Pine in valley.	41 23 31.27	964.7	72 57 51.69	1200.9
New England Cement Works, smoke-stack.	41 22 36.18	1116.1	72 58 39.97	928.8
New Haven City Hall.	41 18 26.57	819.6	72 55 29.87	694.9
Howard 1. 1876.	41 24 31.72	978.5	72 52 18.81	436.9
Giant's Head.	41 25 35.82	1105.0	72 53 59.06	1371.4
Merritt.	41 24 23.65	729.6	72 56 30.69	712.8
Quartz Hill.	41 22 00.41	12.6	72 59 41.37	961.5
Hemlock.	41 22 27.28	841.6	72 59 03.64	84.6
Hotchkiss.	41 23 43.87	1353.4	72 58 53.50	1242.9
Orange.	41 17 58.04	1790.5	72 57 54.16	1260.1
Cone, (New Haven County).	41 17 55.09	1699.5	72 50 58.03	1350.1
Lyd. Hitt's Hill.	41 19 03.61	111.4	72 49 08.89	206.8
Poplar.	41 16 30.49	940.6	72 50 22.65	527.1
Harrison.	41 18 00.48	14.8	72 49 45.16	1050.7
Bradley, (New Haven County).	41 17 14.20	438.1	72 49 28.04	652.6
Apple tree.	41 16 33.22	1024.8	72 51 34.66	806.7
Nichols house, west chimney.	41 17 03.45	106.4	72 49 56.03	1303.9

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
349 12 18	169 12 30	Dead tree	2243. 0	3. 35082
14 11 59	194 11 42	Sperry.	2493. 0	3. 39672
217 35 47	37 36 04	Dead tree	956. 0	2. 98044
140 29 45	320 29 32	Sperry.	704. 7	2. 84802
28 50 04	208 49 13	Sperry	3723. 3	3. 57093
54 28 49	234 28 15	Doolittle.	1454. 4	3. 16269
100 35 30	280 35 08	Bill Hill	788. 8	2. 89697
153 39 17	333 38 51	Sperry.	2074. 1	3. 31684
51 11 25	231 11 08	Bill Hill	763. 4	2. 88275
149 04 36	329 04 15	Sperry.	1440. 1	3. 15839
353 13 34	173 13 38	Hillside	1291. 5	3. 11110
9 51 21	189 51 07	Pine.	2958. 4	3. 47105
6 17 02	186 16 58	Hillside	1200. 8	3. 07948
107 23 42	287 23 34	Bethany South.	297. 3	2. 47323
242 56 01	62 56 29	Hillside	1112. 2	3. 04620
29 40 44	209 40 38	Doolittle.	391. 0	2. 59214
132 03 41	312 02 14	West Rock 2	4138. 5	3. 61684
212 16 10	32 16 52	East Rock 2.	2768. 0	3. 44217
348 11 22	168 12 06	Rabbit Rock	7566. 6	3. 87890
69 18 59	249 15 23	West Rock North.	8097. 5	3. 90835
337 32 08	157 33 58	Rabbit Rock	10153. 6	4. 00662
47 18 25	227 15 56	West Rock North.	7137. 6	3. 85355
314 00 47	134 04 18	Rabbit Rock	10296. 3	4. 01268
11 22 27	191 21 40	West Roçk 2.	8409. 1	3. 92475
161 22 24	341 22 03	Hickox 2	2355. 2	3. 37202
311 01 20	131 02 07	Dead tree.	2192. 4	3. 34091
130 44 03	310 43 17	Hickox 2	2149. 8	3. 33240
341 05 34	161 05 46	Dead tree.	2397. 7	3. 37979
62 45 48	242 44 55	Hickox 2	2097. 1	3. 32161
5 41 38	185 41 31	Hemlock.	2374. 4	3. 37555
184 25 38	4 25 46	West Rock 2	3663. 0	3. 56384
236 18 38	56 20 55	East Rock 2.	5809. 0	3. 76410
63 25 37	243 23 53	Fort Wooster 2	4095. 7	3. 61233
176 05 57	356 05 48	Rabbit Rock.	4840. 5	3. 68489
50 13 51	230 12 39	Cone	3303. 7	3. 51900
133 27 10	313 25 49	Rabbit Rock.	3949. 2	3. 59651
99 50 37	279 48 30	Fort Wooster 2	4553. 3	3. 65833
162 29 54	342 29 31	Cone.	2736. 7	3. 43722
17 27 07	197 26 42	Poplar	2910. 2	3. 46393
84 24 01	264 23 13	Cone.	1703. 5	3. 23134
43 18 39	223 18 03	Poplar	1853. 1	3. 26791
164 24 56	344 24 45	Harrison.	1482. 3	3. 17093
272 52 07	92 52 54	Poplar	1678. 0	3. 22479
223 24 58	43 26 10	Harrison.	3706. 9	3. 56901
243 01 23	63 01 41	Bradley	731. 0	2. 86390
188 10 53	8 11 00	Harrison.	1777. 4	3. 24978

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Summer house.	41 16 22.66	699.0	72 50 35.43	824.6
Burnes's pine.	41 18 32.29	996.1	72 49 40.28	937.0
Branford, Congregational church. 1876.	41 16 52.22	1610.9	72 48 40.61	945.0
New Haven, Alms House cupola.	41 18 55.57	1714.3	72 57 08.48	197.2
Jewett.	41 18 46.91	1447.1	72 58 22.14	515.0
Cedar, (New Haven County).	41 17 43.14	1330.8	72 57 44.57	1037.0
Round Hill House.	41 17 41.00	1264.8	72 58 23.73	552.1
Westville.	41 19 35.65	1099.8	72 58 16.80	390.7
Westville, Methodist Episcopal church.	41 19 42.80	1320.3	72 57 41.27	959.7
West Haven, Congregational church. 1876.	41 16 17.48	539.2	72 57 01.88	43.8
West Haven Key Works, chimney.	41 16 46.26	1427.1	72 56 25.12	584.6
New Haven Scientific School, observatory tower.	41 18 42.77	1319.4	72 55 32.63	759.0
Howard 2. 1877.	41 24 51.14	1577.7	72 52 33.05	767.5
Brethren.	41 24 53.18	1640.6	72 55 48.69	1130.7
York Hill.	41 24 32.06	989.1	72 55 09.79	227.4
Road.	41 24 18.51	571.0	72 56 40.25	934.9
Watch House.	41 15 14.99	462.4	72 40 39.13	911.0

HOUSATONIC RIVER TO NEW YORK STATE LINE.

Brushy Ridge.	41 09 24.294	749.5	73 29 00.900	21.0
Cumpo. 1834.	41 06 50.041	1543.8	73 21 00.521	12.2
Gorham.	41 11 00.290	8.9	73 23 45.680	1064.7
Copp's Island. 1834–'85.	41 03 34.411	1061.6	73 23 15.477	361.4

CONNECTICUT RIVER TO HOUSATONIC RIVER—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
103 41 00	283 39 01	Fort Wooster 2	4311.1	3.63459
230 56 19	50 56 27	Poplar.	383.3	2.58355
217 04 52	37 05 13	Lyd. Hitt's Hill	1210.9	3.08311
6 36 25	186 36 22	Harrison.	987.8	2.99468
74 14 47	254 13 40	Poplar	2467.7	3.39229
121 34 25	301 33 54	Bradley.	1295.4	3.11240
157 26 53	337 26 31	West Rock 2	2032.7	3.30808
249 00 41	69 02 28	East Rock 2.	4039.0	3.60627
203 31 09	23 31 36	West Rock 2	2338.9	3.36902
252 38 06	72 40 42	East Rock 2.	5745.8	3.75935
180 49 44	0 49 46	West Rock 2	4112.1	3.61406
231 23 27	51 25 38	East Rock 2.	5899.7	3.77083
193 04 27	13 04 55	West Rock 2	4288.4	3.63229
235 49 36	55 52 13	East Rock 2.	6673.0	3.82432
231 37 22	51 37 45	West Rock 2	1032.4	3.01386
350 04 37	170 04 52	Orange.	3056.9	3.48528
177 39 49	357 39 48	West Rock 2	420.7	2.62396
113 28 20	293 27 22	Bill Hill.	2207.5	3.34391
209 46 13	29 47 56	East Rock 2	7285.8	3.86245
172 08 10	352 07 44	West Rock 2.	6818.7	3.83370
206 56 30	26 57 48	East Rock 2	6097.3	3.78514
163 03 06	343 02 15	West Rock 2.	6132.9	3.78766
219 56 59	39 57 43	East Rook 2	2401.3	3.38045
127 04 11	307 02 46	West Rock 2.	3770.5	3.57640
346 47 05	166 47 58	Rabbit Rock	8223.4	3.91505
78 31 35	258 29 13	High Rock.	5092.6	3.70694
321 26 36	141 29 39	Rabbit Rock	10314.3	4.01344
270 46 22	90 48 31	Howard 2.	4544.2	3.65746
323 18 48	143 21 25	Rabbit Rock	9246.6	3.96598
51 25 18	231 23 35	West Rock North.	4608.3	3.66354
234 27 00	54 27 06	Merritt	272.9	2.43606
270 36 40	90 37 01	High Rock.	751.0	2.87563
241 44 45	61 45 52	Highlands	2684.9	3.42893
337 09 30	157 10 26	Falkner's Island L. H.	5081.7	3.70601

HOUSATONIC RIVER TO NEW YORK STATE LINE.

239 25 08.5	59 34 21.6	Tashua	22702.1	4.356066
69 48 20.4	249 40 49.9	Round Hill.	17028.5	4.231177
135 57 21.8	315 52 18.3	Bald Hill (Fairfield County)	15453.1	4.189014
207 10 33.2	27 14 29.7	Tashua.	18307.9	4.262639
116 08 04.5	296 04 49.5	Bald Hill (Fairfield County)	7680.9	3.885411
234 55 11.5	55 00 57.0	Tashua.	14915.9	4.173650
156 05 15.7	336 01 41.1	Bald Hill (Fairfield County)	18747.8	4.272951
207 15 34.2	27 20 59.4	Tashua.	25115.3	4.399938

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Black Rock L. H. 1833–'85.	41 08 32.582	1005.2	73 13 04.093	95.4
Greenfield.	41 11 32.294	996.3	73 17 18.689	435.5
Pine Creek Point 3. 1882.	41 07 07.368	227.3	73 15 42.989	1002.9
Cumpo 2. 1882.	41 06 49.229	1518.7	73 20 58.107	1355.6
Stratford Point L. H. 1881–'85.	41 09 07.220	222.7	73 06 13.475	314.2
Bridgeport Harbor L. H. 1882.	41 09 24.180	746.0	73 10 49.380	1151.3
Penfield Reef L. H. 1882.	41 07 01.574	48.5	73 13 21.008	490.1
Chimon's Island 2. 1882.	41 04 04.776	147.3	73 23 29.374	685.8
Kensie's Point.	41 07 33.240	1025.5	73 16 22.519	525.3
McDonald.	41 13 08.444	260.5	73 09 11.256	262.1
Stratford Beacon. 1881–'84.	41 09 47.114	1453.5	73 06 14.890	347.1
Stamford Harbor L. H. 1882–'85.	41 00 49.212	1518.2	73 32 34.740	811.8
Long Neck 2. 1882.	41 02 10.410	321.2	73 28 41.854	977.7
Norwalk Islands L. H. 1882–'85.	41 02 55.744	1719.7	73 25 10.528	245.8
Little Captain's Island 2. 1882.	40 59 24.972	770.3	73 36 31.098	726.9
Greenwich Point 2. 1882.	41 00 14.199	438.0	73 34 26.133	610.7
Great Captain's Island L. H. 1882–'85.	40 58 57.103	1761.5	73 37 26.399	617.1
Round Hill 2. 1882.	41 06 13.022	401.7	73 40 26.230	612.1
Bald Hill 2. 1882.	41 12 49.823	1537.1	73 28 41.711	971.7
Stratford Shoal (Middle Ground) L. H., N. Y. 1881–'85.	41 03 35.784	1104.0	73 06 06.106	142.6
East Bluff, N. Y.	40 56 21.212	654.3	73 28 18.017	421.4
Bennet.	41 16 40.118	1237.6	73 06 05.813	135.3
Stratford Hill.	41 13 08.365	258.0	73 09 10.790	251.3

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
57 14 44.9	237 08 03.0	Copp's Island	16975.1	4.229813
168 14 53.7	348 13 36.5	Tashua.	13400.3	4.127113
202 53 01.9	22 54 32.4	Tashua	8222.8	3.915022
98 36 48.0	278 29 18.1	Bald Hill (Fairfield County).	16092.4	4.206620
58 09 29.8	238 04 32.4	Copp's Island	12437.5	4.094734
234 38 20.1	54 40 04.6	Black Rock L. H.	4543.9	3.657426
135 52 16.5	315 47 11.4	Bald Hill (Fairfield County)	15510.2	4.190618
210 20 46.7	30 23 11.1	Greenfield.	10120.6	4.005207
134 27 53.5	314 22 05.8	Tashua	17218.0	4.235982
220 56 38.8	40 59 55.0	Milford.	10590.8	4.024927
274 37 27.6	94 40 29.2	Stratford Point L. H., 1881	6454.5	3.809862
153 02 12.4	332 59 26.4	Tashua.	12935.6	4.111787
248 43 12.3	68 47 53.5	Stratford Point L. H., 1881	10698.5	4.029325
218 46 53.2	38 48 32.9	Bridgeport Harbor L. H., 1882.	5644.4	3.751617
155 49 01.8	335 45 36.3	Bald Hill (Fairfield County)	17760.2	4.249448
212 01 32.2	32 05 36.0	Greenfield.	16289.4	4.211906
78 06 04.4	258 03 03.2	Cumpo 2	6571.0	3.817633
52 38 32.9	232 34 01.5	Copp's Island.	12131.3	4.083908
119 30 51.4	299 27 00.6	Tashua	9364.7	3.971496
267 05 22.2	87 10 35.7	Milford.	11095.6	4.045150
131 28 02.1	311 22 15.3	Tashua	16354.7	4.213644
225 51 05.3	45 54 22.5	Milford.	9718.4	3.987596
193 43 23.2	13 45 56.4	Bald Hill (Fairfield County)	22886.1	4.359572
132 18 00.4	312 12 51.0	Round Hill.	14861.3	4.172056
65 18 04.9	245 15 32.0	Stamford Harbor L. H.	5989.7	3.777407
244 10 09.5	64 13 34.7	Chimon's Island 2.	8105.4	3.908777
69 25 36.3	249 20 44.7	Stamford Harbor L. H.	11086.8	4.044807
74 11 59.6	254 09 40.8	Long Neck 2.	5130.1	3.710126
156 29 55.7	336 27 21.6	Round Hill	13733.4	4.137779
244 47 04.7	64 49 39.8	Stamford Harbor L. H.	6104.6	3.785657
142 51 15.2	322 47 19.0	Round Hill	13898.4	4.142966
62 32 26.2	242 31 04.2	Little Captain's Island 2.	3291.9	3.517451
162 42 58.0	342 41 00.2	Round Hill	14089.3	4.148890
243 04 24.4	63 07 35.7	Stamford Harbor L. H.	7643.8	3.883308
245 40	65 40	Round Hill	11.3	1.053326
233 14 27.0	53 22 10.7	Bald Hill (Fairfield County).	20486.6	4.311470
212 46	32 46	Bald Hill (Fairfield County)	1.2	0.094139
254 44 43.2	74 53 44.0	Tashua.	19795.3	4.296561
133 13 32.3	313 08 57.5	Black Rock L. H.	13377.9	4.126389
200 22 33.2	20 25 44.4	Milford.	19440.2	4.288701
177 02 27.6	357 02 12.0	Long Neck	10786.3	4.032874
144 02 34.2	323 59 45.8	Stamford Harbor L. H.	10216.2	4.009290
242 36 00.1	62 41 32.2	West Rock	13179.8	4.119908
311 26 59.4	131 30 10.8	Milford.	9021.5	3.955276
119 29 40.4	299 25 49.3	Tashua	9375.4	3.971988
267 04 27.5	87 09 40.7	Milford.	11084.9	4.044730

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Sherwood.	41 12 09.039	278.8	73 13 24.066	560.7
Pavement.	41 11 37.344	1152.0	73 17 17.348	404.3
Palmer (Fairfield County).	41 03 40.869	1260.7	73 34 06.194	144.6
Port Chester, N. Y.	41 00 09.156	282.4	73 40 22.767	532.1
Stratford Point.	41 09 28.717	885.9	73 07 06.122	142.7
Bussing, N. Y.	41 09 36.327	1120.6	73 40 47.576	1109.2
Merwin.	41 14 09.094	280.5	73 19 57.602	1341.4
Pine Creek Point 2. 1834.	41 07 13.960	430.6	73 15 34.154	796.8
Little Captain's Island.	40 59 24.929	769.0	73 36 31.006	724.7
High Ridge.	41 16 24.204	746.7	73 30 09.064	211.0
Loaf Hill.	41 19 34.703	1070.5	73 29 55.064	1280.6
Center Redding.	41 19 00.618	19.1	73 22 57.912	1347.0
Wheeler.	41 15 13.485	416.0	73 19 41.398	963.8
Goodridge.	41 19 41.892	1292.3	73 18 49.191	1143.9
Moose Hill (Fairfield County).	41 19 11.726	361.7	73 12 06.091	141.7
Barn Hill.	41 20 40.418	1246.9	73 11 06.770	157.4
Riggs.	41 24 44.146	1361.9	73 07 48.735	1131.9
Purdy, N. Y.	41 03 10.123	312.3	73 41 36.082	842.6
Fields West, N. Y.	41 02 17.376	536.0	73 43 34.482	805.4
Pine Swamp Hill.	41 21 09.102	280.8	73 16 29.206	678.9
Great Hill East.	41 21 53.662	1655.5	73 07 01.364	31.7
Chestnut Tree Hill.	41 26 26.530	818.5	73 05 42.479	986.2
Noroton.	41 03 16.698	515.1	73 30 53.073	1239.4

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
160 38 01.2	340 36 57.1	Tashua	6828.2	3.834303
252 44 41.1	72 47 28.0	Stratford Hill.	6177.9	3.790838
203 06 35.4	23 08 05.0	Tashua	8067.3	3.906727
259 46 53.7	79 49 27.4	Sherwood.	5523.0	3.742177
117 58 09.7	297 54 00.2	Round Hill	10029.2	4.001266
213 53 19.3	33 56 40.0	Brushy Ridge.	12766.3	4.106064
179 38 25.2	359 38 23.2	Round Hill	11229.5	4.050359
233 22 29.7	53 26 36.9	Palmer.	10956.1	4.039658
135 50 58.8	315 45 45.7	Tashua	15882.0	4.200906
228 03 35.5	48 07 26.4	Milford.	10979.0	4.040561
250 29 43.5	70 37 41.5	Bald Hill (Fairfield County)	17939.8	4.253816
355 21 42.8	175 21 57.1	Round Hill.	6287.6	3.798484
42 23 42.8	222 21 12.5	Gorham	7884.0	3.896748
78 43 28.5	258 37 43.1	Bald Hill (Fairfield County).	12449.1	4.095139
182 48 50.6	2 49 12.2	Tashua	15563.1	4.192096
250 37 11.6	70 42 45.8	Stratford Point.	12556.5	4.098870
156 29 34.1	336 26 59.9	Round Hill	13735.5	4.137844
203 10 56.2	23 12 31.3	Palmer.	8589.5	3.933970
342 53 18.0	162 54 15.6	Bald Hill (Fairfield County)	6918.4	3.840006
49 49 44.5	229 42 43.8	Bussing.	19482.2	4.289639
289 16 43.0	109 26 32.8	Tashua	22041.4	4.343238
352 12 21.0	172 13 09.4	Bald Hill (Fairfield County).	12605.5	4.100558
299 22 58.1	119 28 12.6	Tashua	12732.3	4.104907
35 00 33.1	214 56 46.4	Bald Hill (Fairfield County).	13959.0	4.144855
70 39 01.2	250 33 05.1	Bald Hill (Fairfield County)	13339.9	4.125152
119 29 38.9	299 22 54.0	Loaf Hill.	16396.2	4.214743
324 49 34.6	144 52 05.0	Tashua	9208.1	3.964170
77 36 32.7	257 33 48.5	Center Redding.	5923.0	3.772543
31 43 55.2	211 41 59.6	Tashua	7756.4	3.889662
95 42 21.3	275 37 55.1	Goodridge.	9420.8	3.974090
30 19 57.5	210 17 22.7	Tashua	10812.3	4.033919
80 30 37.2	260 25 31.8	Goodridge.	10902.9	4.037542
284 53 43.0	104 58 43.9	Hickox 2	10938.9	4.038973
30 52 14.1	210 47 28.4	Tashua.	19626.8	4.292850
196 11 50.8	16 12 37.0	Round Hill	5880.4	3.769403
342 56 11.9	162 57 00.0	Port Chester.	5839.3	3.766362
298 13 26.0	118 18 03.9	Little Captain's Island	11234.4	4.050551
311 25 40.0	131 27 45.8	Port Chester.	5975.7	3.776387
241 12 17.2	61 18 01.3	Riggs	13793.7	4.139682
348 40 47.8	168 41 45.8	Tashua.	10421.6	4.017934
84 06 22.6	264 00 07.4	Pine Swamp Hill	13270.5	4.122887
168 11 06.2	348 10 34.9	Riggs.	5373.3	3.730245
12 17 14.7	192 16 22.5	Great Hill East	8615.1	3.935260
42 52 40.9	222 51 17.4	Riggs.	4309.4	3.634418
112 12 30.4	292 06 14.1	Round Hill	14435.1	4.159419
47 52 06.3	227 48 24.5	Little Captain's Island.	10651.4	4.027408

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Sandford, N. Y.	41 01 13.464	415.3	73 39 56.961	1330.9
Watermelon, N. Y.	41 21 53.814	1660.2	73 43 16.367	380.4
Round Mount., N. Y.	41 25 06.366	196.4	73 32 25.645	595.5
Bailey, N. Y.	41 18 43.793	1351.0	73 33 06.067	141.1
Haines, N. Y.	41 54 37.741	1164.5	73 34 08.072	186.0
Prospect Hill.	41 58 45.109	1391.8	73 23 06.278	144.5
Preston, N. Y.	41 42 36.698	1132.1	73 31 04.370	101.0
Ellsworth.	41 48 07.776	239.9	73 27 12.469	287.8
Alander Mountain (Borden), Mass.	42 05 15.057	464.6	73 30 18.725	430.4
Bell Island.	41 03 19.80	610.8	73 26 01.76	41.1
West Marsh.	41 04 46.56	1436.3	73 24 36.24	846.0
Cockenoe's Island 2. 1882.	41 05 01.40	43.2	73 21 21.08	492.0
Frost Point 2. 1882.	41 06 55.46	1710.8	73 18 33.78	788.1
Canal.	41 05 58.33	1799.3	73 22 26.19	611.2
Horseneck, First Congregational church spire. 1882.	41 02 07.19	221.8	73 37 24.64	575.6
Americus, tower of club house, now called Indian Harbor hotel.	41 00 37.27	1149.7	73 37 09.36	218.7
Shippan.	41 01 32.23	994.2	73 31 10.65	248.8
Wallack.	41 02 11.49	354.5	73 30 22.80	532.6
Little Captain's Island 3. 1882.	40 59 19.97	616.0	73 36 38.95	910.4
Field Point.	41 00 06.50	200.5	73 37 37.92	886.2
Manursing Island summer house, southern of two on north end of island, N. Y.	40 58 46.95	1448.3	73 39 25.01	584.6
Mead. 1882.	40 59 52.00	1604.0	73 39 03.26	76.2
Lockwood's (Oliver) house, north chimney.	41 01 24.68	761.3	73 33 31.48	735.5

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
304 48 16.4	124 50 31.5	Little Captain's Island	5863.0	3.768122
240 56 13.9	61 00 04.2	Palmer.	9370.2	3.971747
274 26 04.7	94 35 18.6	Wooster	19544.9	4.291033
46 08 52.2	226 03 04.9	Dickerson.	16980.9	4.229961
329 45 21.1	149 47 25.1	Wooster	8654.3	3.937230
57 11 12.3	236 58 15.1	Dickerson.	32594.9	4.513149
112 30 06.0	292 23 22.9	Watermelon	15353.6	4.186209
184 32 51.3	4 33 18.0	Round Mount.	11839.6	4.073339
278 25 49.1	98 39 37.2	Ivy	28911.1	4.461065
207 49 42.6	27 55 09.8	Bald Peak.	24067.6	4.381432
311 46 39.1	131 53 05.5	Ivy	17884.7	4.252482
40 46 10.8	220 36 42.7	Plymouth.	30098.3	4.478541
8 15 04.8	188 14 08.3	Osborne	13710.0	4.137038
80 41 11.4	260 34 11.2	Clove.	14803.9	4.170377
182 53 50.3	2 54 39.3	Bald Peak	33349.5	4.523089
247 47 50.3	67 57 00.3	Ivy.	20537.4	4.312546
254 51 24.0	74 54 18.0	Bald Peak	6180.0	3.790991
320 22 32.7	140 27 22.2	Prospect Hill.	15611.0	4.193430
248 40 47	68 42 27	Chimon's Island 2	3819.1	3.58196
301 47 42	121 48 16	Norwalk Islands L. H., 1882.	1407.7	3.14851
309 32 22	129 33 06	Chimon's Island 2	2024.2	3.30626
36 43 49	216 42 53	Bell Island.	3339.3	3.52366
59 45 41	239 44 17	Chimon's Island 2	3466.9	3.53994
84 16 47	264 14 39	West Marsh.	4578.4	3.66071
249 08 51	69 10 17	Kensie's Point	3276.5	3.51541
264 42 51	84 44 43	Pine Creek Point 3.	4001.3	3.60220
319 07 41	139 08 24	Cockenoe's Island 2	2322.4	3.36593
22 50 19	202 49 37	Chimon's Island 2.	3800.6	3.57985
309 52 12	129 54 09	Greenwich Point 2	5435.4	3.73523
0 24 09	180 24 08	Great Captain's Island L. H., 1882.	5864.1	3.76820
280 33 12	100 34 59	Greenwich Point 2	3880.4	3.58888
338 08 43	158 09 08	Little Captain's Island 2.	2402.8	3.38071
251 16 06	71 17 44	Long Neck 2	3669.9	3.56466
337 10 10	157 12 03	East Bluff.	10408.3	4.01738
270 48 10	90 49 16	Long Neck 2	2358.2	3.37258
42 42 28	222 41 57	Shippan.	1648.1	3.21698
163 24 28	343 24 08	Americus	2488.3	3.39590
241 40 09	61 41 36	Greenwich Point 2.	3526.4	3.54734
215 06 29	35 06 48	Americus.	1160.5	3.06464
316 09 20	136 09 59	Little Captain's Island 3.	1989.7	3.29878
222 57 44	42 59 13	Americus	4651.1	3.66756
263 32 37	83 33 55	Great Captain's Island L. H., 1882.	2790.6	3.44570
242 18 24	62 19 39	Americus	3005.9	3.47797
306 47 03	126 48 07	Great Captain's Island L. H., 1882.	2827.4	3.45139
309 31 48	129 32 25	Stamford Harbor L. H.	1719.0	3.23527
30 25 58	210 25 22	Greenwich Point 2.	2521.6	3.40167

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Greenfield church spire. 1882.	41 10 36.82	1135.9	73 17 34.19	797.0
Fairfield, Congregational church spire. 1882.	41 08 35.56	1097.0	73 15 02.06	48.0
Fairfield, Episcopal church spire. 1882.	41 08 32.58	1005.0	73 15 02.89	67.4
Black (or Huncher's) Rock Beacon. 1882.	41 07 14.36	443.0	73 13 03.79	88.4
Scott's house, southwest chimney.	41 07 31.50	971.7	73 16 22.22	518.4
Lone Chimney.	41 09 18.30	564.5	73 13 05.11	119.1
Bridgeport, St. Augustine Catholic church spire. 1882.	41 10 48.70	1502.3	73 11 45.00	1048.8
Bridgeport, First Presbyterian church spire. 1882.	41 10 29.30	903.9	73 11 42.32	986.5
Bridgeport, First Congregational church spire. 1882.	41 10 37.60	1159.9	73 11 26.42	615.8
Bridgeport, Second Congregational church spire. 1882.	41 10 32.60	1005.7	73 11 24.26	565.5
Bridgeport, inner (N. E.) Beacon. 1833–'82.	41 09 58.88	1816.4	73 10 35.60	830.0
Bridgeport, outer (S. W.) Beacon. 1833–'82.	41 09 47.01	1450.2	73 10 45.86	1069.1
East Bridgeport, Catholic church spire. 1884.	41 10 54.55	1682.8	73 10 44.72	1042.3
Seaside Park, Soldiers' Monument.	41 09 41.58	1282.7	73 11 11.92	277.9
Southport, Episcopal church spire. 1882.	41 08 00.25	7.7	73 17 16.84	392.7
Southport, Congregational church spire. 1882.	41 08 06.28	193.7	73 17 12.90	300.8
Southport, outer Beacon. 1882.	41 07 18.86	581.8	73 17 15.72	366.7
Southport, inner Beacon. 1882.	41 07 33.45	1031.9	73 17 15.45	360.4
Jennings' (Andrew) house, cupola.	41 07 17.62	543.5	73 18 09.88	230.5
Sherwood's (Arthur) house, chimney.	41 06 47.82	1475.1	73 19 56.75	1324.0
Burnham's barn, cupola.	41 06 51.90	1601.0	73 21 02.98	69.5
Cockenoe's Island house, southwest chimney.	41 04 59.78	1844.1	73 21 29.47	687.9
Goose Island, westernmost of two trees.	41 04 14.29	440.8	73 22 21.00	490.4

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
104 50 32	284 43 12	Bald Hill (Fairfield County)	16086.4	4.20646
191 55 22	11 55 32	Greenfield.	1749.0	3.24280
271 53 40	91 54 58	Black Rock L. H.	2752.8	3.43978
19 20 22	199 19 55	Pine Creek Point 3.	2883.2	3.45988
269 59 18	90 00 36	Black Rock L. H.	2770.4	3.44255
19 35 26	199 35 00	Pine Creek Point 3.	2790.2	3.44563
97 10 46	277 08 35	Kensie's Point	4672.4	3.66954
179 50 03	359 50 03	Black Rock L. H.	2412.9	3.38254
70 05 51	250 04 25	Frost Point 2	3264.4	3.51381
172 27 05	352 27 05	Kensie's Point.	54.2	1.73410
359 02 00	179 02 01	Black Rock L. H.	1410.4	3.14934
54 52 24	234 50 14	Kensie's Point.	5630.3	3.75053
333 33 36	153 34 13	Bridgeport Harbor L. H., 1882	2912.3	3.46423
23 42 53	203 42 01	Black Rock L. H.	4586.0	3.66143
27 54 31	207 53 37	Black Rock L. H.	4074.2	3.61004
154 02 56	334 00 45	Tashua.	10587.2	4.02478
30 34 16	210 33 12	Black Rock L. H.	4478.4	3.65112
339 07 15	159 07 39	Bridgeport Harbor L. H., 1882.	2424.0	3.38453
32 10 06	212 09 00	Black Rock L. H.	4373.5	3.64083
338 55 41	158 56 04	Bridgeport Harbor L. H., 1882.	2261.7	3.35443
16 42 00	196 41 51	Bridgeport Harbor L. H., 1882	1117.6	3.04827
149 23 56	329 21 01	Tashua.	12151.8	4.08464
6 38 11	186 38 09	Bridgeport Harbor L. H., 1882	709.0	2.85065
54 32 53	234 31 22	Black Rock L. H.	3957.3	3.59740
145 39 12	325 36 23	Tashua	10587.7	4.02480
250 29 26	70 35 41	Milford.	14066.0	4.14817
315 36 23	135 36 38	Bridgeport Harbor L. H., 1882	751.2	2.87576
50 52 20	230 51 06	Black Rock L. H.	3372.3	3.52793
67 01 18	246 58 52	Cumpo 2	5607.4	3.74876
303 19 19	123 19 55	Kensie's Point.	1516.5	3.18084
310 55 39	130 56 12	Kensie's Point	1555.7	3.19193
40 48 53	220 48 00	Frost Point 2.	2886.6	3.46039
250 19 12	70 19 47	Kensie's Point	1317.9	3.11988
279 17 46	99 18 47	Pine Creek Point 3.	2192.0	3.34085
270 17 20	90 17.55	Kensie's Point	1234.8	3.09160
50 43 44	230 41 03	Cockenoe's Island 2.	7406.3	3.86960
275 15 21	95 16 58	Pine Creek Point 3	3441.1	3.53670
39 12 45	219 12 29	Frost Point 2.	882.2	2.94555
263 03 14	83 04 09	Frost Point 2	1950.1	3.29005
30 57 14	210 56 19	Cockenoe's Island 2.	3827.8	3.58295
135 57 39	315 52 37	Bald Hill (Fairfield County)	15372.0	4.18673
211 08 17	31 10 45	Greenfield.	10108.3	4.00468
58 47 22	238 46 03	Chimon's Island 2	3273.1	3.51496
143 45 57	323 45 20	Canal.	2239.4	3.35014
107 30 55	287 29 26	West Marsh	3310.5	3.51989
223 53 48	43 54 27	Cockenoe's Island 2.	2017.1	3.30472

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Calf-pasture Island, dead tree.	41 04 56.54	1744.1	73 23 03.48	81.2
Bett's Island house, south-chimney.	41 04 21.72	670.0	73 23 16.82	392.7
Green's Ledge spindle.	41 02 36.35	1121.3	73 25 22.57	527.2
Dorlon's Hotel cupola.	41 05 13.21	407.5	73 24 07.70	179.7
Chimon's Island house, chimney.	41 04 01.64	50.6	73 23 29.28	683.7
Norwalk River Beacon. 1882.	41 04 23.70	731.1	73 24 22.10	515.9
Tavern Island flag-staff. 1882.	41 03 39.01	1203.4	73 25 20.82	486.2
Wilson's Point, depot cupola.	41 03 46.65	1439.0	73 25 45.73	1067.7
Colyer's house cupola.	41 03 12.80	394.8	73 27 29.76	695.0
Van, cupola of *Shippan Point House.*	41 01 40.87	1260.7	73 31 10.84	253.3
Yale Lock Works, chimney lightning-rod.	41 02 44.72	1379.5	73 32 12.76	298.0
Old factory chimney.	41 02 22.54	695.3	73 32 38.14	890.8
Stamford, Congregational church spire. 1882.	41 03 08.94	275.8	73 32 24.22	565.6
Stamford, Baptist church spire. 1882.	41 03 18.68	576.2	73 32 21.29	497.2
Watch-house on rock, west gable.	41 02 23.64	729.2	73 29 21.98	513.4
Collender's house cupola.	41 02 29.50	910.0	73 28 42.84	1000.6
Dye Works, southwest chimney.	41 02 52.30	1613.3	73 30 15.60	364.3
Cove Mills cupola.	41 02 56.62	1746.6	73 29 58.38	1363.4
Black cupola, rod.	41 03 14.27	440.2	73 30 53.16	1241.5
Black cupola, southwest corner of railing.	41 03 14.22	438.7	73 30 53.25	1243.6
Stratford, Episcopal church spire. 1884.	41 11 18.68	576.3	73 07 50.06	1166.6
Stratford, Congregational church spire. 1884.	41 11 33.20	1024.2	73 07 51.82	1207.6
Hospital.	41 11 21.21	654.3	73 10 00.76	17.7

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
204 32 17	24 32 41	Canal	2095.3	3.32125
266 24 19	86 25 26	Cockenoe's Island 2.	2395.2	3.37934
358 46 12	178 46 13	Copp's Island	1459.8	3.16428
112 27 56	292 27 04	West Marsh.	2006.1	3.30235
145 40 12	325 39 46	Bell Island	1623.0	3.21031
238 52 45	58 54 08	Copp's Island.	3466.5	3.53989
338 11 36	158 12 10	Copp's Island	3282.8	3.51624
275 20 02	95 21 52	Cockenoe's Island 2.	3906.1	3.59174
70 05 22	250 03 42	Bell Island	3787.2	3.57832
131 33 56	311 33 12	West Marsh.	2089.2	3.31998
222 48 58	42 50 14	Canal	3980.2	3.59991
49 44 09	229 43 04	Bell Island.	3049.9	3.48428
272 45 54	92 47 16	Copp's Island	2930.2	3.46690
58 11 59	238 11 32	Bell Island.	1124.8	3.05108
276 07 38	96 09 17	Copp's Island	3527.1	3.54742
24 15 10	204 15 00	Bell Island.	908.7	2.95840
263 59 51	84 00 49	Bell Island	2066.3	3.31520
41 11 15	221 10 28	Long Neck 2.	2556.8	3.40770
255 18 46	75 20 24	Long Neck 2	3597.7	3.55603
337 42 15	157 44 09	East Bluff.	10656.1	4.02760
282 06 30	102 08 48	Long Neck 2	5038.6	3.70231
8 12 05	188 11 51	Stamford Harbor L. H.	3600.1	3.55631
273 51 34	93 54 09	Long Neck 2	5531.8	3.74287
358 25 17	178 25 19	Stamford Harbor L. H.	2880.3	3.45943
3 15 54	183 15 47	Stamford Harbor L. H.	4317.4	3.63522
39 52 48	219 50 06	Little Captain's Island 2.	9000.4	3.95426
3 54 03	183 53 54	Stamford Harbor L. H.	4621.4	3.66477
72 44 19	252 41 00	Horseneck spire, 1882.	7420.1	3.87041
293 31 34	113 32 00	Long Neck 2	1022.1	3.00951
58 01 02	237 59 51	Shippan.	2993.2	3.47613
357 46 15	177 46 16	Long Neck 2	589.5	2.77044
76 37 31	256 36 25	Wallack.	2400.1	3.38023
300 32 09	120 33 11	Long Neck 2	2542.6	3.40528
7 36 11	187 36 06	Wallack.	1269.9	3.10377
308 33 49	128 34 39	Long Neck 2	2286.3	3.35914
22 16 36	202 16 20	Wallack.	1504.3	3.17734
302 42 11	122 43 37	Long Neck 2	3644.9	3.56168
27 56 48	207 55 41	Stamford Harbor L. H.	5065.0	3.70458
302 39 54	122 41 20	Long Neck 2	3645.9	3.56181
27 55 53	207 54 46	Stamford Harbor L. H.	5062.6	3.70437
128 33 16	308 28 32	Tashua	12838.7	4.10852
246 45 26	66 49 46	Milford.	10001.8	4.00008
127 04 13	306 59 30	Tashua	12531.4	4.09800
249 14 29	69 18 50	Milford.	9871.9	3.99440
138 32 26	318 29 08	Tashua	10568.2	4.02400
252 26 02	72 31 48	Milford.	12832.8	4.10832

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Calf, south gable of Alexander Lutz's house.	40 59 27.16	837.8	73 38 30.60	715.3
Mayo's (Captain) house, cupola.	41 00 45.12	1391.8	73 38 02.31	54.0
Captain Knapp's Island, watch-house.	41 00 39.65	1223.1	73 35 58.62	1369.9
Rock (Fairfield County).	41 00 06.57	202.7	73 37 41.22	963.4
Great Captain's Island tree.	40 58 55.96	1726.2	73 37 47.42	1108.6
Shippan Point, old chimney.	41 01 28.00	863.7	73 31 12.02	280.8
Ferris, cupola of the "Old Greenwich Point House."	41 01 04.14	127.7	73 33 49.71	1161.5
Spindle.	41 00 21.54	664.5	73 36 44.77	1046.2
Wells.	41 14 18.20	561.4	73 07 03.23	75.2
Fairfield.	41 09 23.92	737.9	73 15 33.68	785.3
Black Rock. 1833.	41 08 38.92	1200.6	73 12 57.24	1334.9
Black Rock 2. 1834.	41 08 35.04	1080.9	73 12 58.13	1355.7
Stratford spire, cock. 1833.	41 11 19.44	599.7	73 07 50.17	1169.1
Stratford spire, hen. 1833.	41 11 32.84	1013.1	73 07 51.56	1201.5
Stratford Point L. H. 1833.	41 09 07.24	223.4	73 06 13.18	307.4
Stratford Beacon. 1833.	41 09 47.05	1451.4	73 06 14.82	345.5
Old Farms.	41 14 53.06	1636.8	73 09 18.82	438.2
Chestnut.	41 14 13.50	416.4	73 14 14.61	340.3
Stanwich.	41 06 33.32	1027.8	73 36 51.06	1191.4
Lockwood.	41 05 34.61	1067.6	73 29 04.16	97.1
Davenport.	41 07 34.72	1071.0	73 31 42.73	996.8
Webb.	41 06 55.01	1696.9	73 34 09.84	229.6
Nash.	41 06 04.80	148.1	73 25 41.60	970.7

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
221 16 19	41 17 12	Americus	2877.9	3.45907
301 41 58	121 42 40	Great Captain's Island L. H., 1882.	1764.1	3.24653
281 04 33	101 05 08	Americus	1260.8	3.10064
345 51 30	165 51 54	Great Captain's Island L. H., 1882.	3436.2	3.53608
20 59 08	200 58 42	Little Captain's Island 3	2632.4	3.42036
87 28 03	267 27 17	Americus.	1654.6	3.21870
218 10 48	38 11 09	Americus	1204.9	3.08094
314 38 10	134 38 51	Little Captain's Island 3.	2045.7	3.31085
185 49 33	5 49 39	Field Point	2186.9	3.33982
265 53 04	85 53 18	Great Captain's Island L. H., 1882.	492.4	2.69240
193 52 11	13 52 12	Shippan	134.4	2.12821
249 32 09	69 33 48	Long Neck 2.	3744.0	3.57334
213 54 08	33 54 20	Lockwood's house	763.4	2.88277
284 43 31	104 44 20	Stamford Harbor L. H.	1811.2	3.25798
20 29 15	200 28 48	Great Captain's Island L. H., 1882	2780.7	3.44416
130 10 29	310 10 13	Americus.	752.1	2.87628
0 25 58	180 25 56	Stratford Point	8930.4	3.95087
54 04 02	234 02 38	Stratford Hill.	3669.8	3.56464
183 44 09	3 44 30	Tashua	11559.5	4.06294
232 09 24	52 13 36	Stratford Hill.	11294.6	4.05287
167 23 58	347 22 36	Tashua	13242.5	4.12197
212 23 38	32 26 07	Stratford Hill.	9846.0	3.99326
174 46 08	354 45 51	Sherwood	6629.2	3.82146
258 33 32	78 37 24	Stratford Point.	8373.8	3.92292
71 47 16	251 42 11	Fairfield	11377.1	4.05603
128 28 50	308 24 06	Tashua.	12821.5	4.10794
69 46 36	249 41 32	Fairfield	11482.6	4.06004
147 55 52	327 55 00	Stratford Hill.	3477.1	3.54122
92 18 24	272 12 15	Fairfield.	13079.8	4.11660
134 26 52	314 21 04	Tashua.	17221.9	4.23608
131 28 04	311 22 17	Tashua	16357.6	4.21372
225 50 22	45 53 39	Milford.	9718.5	3.98760
342 48 52	162 50 19	Stratford Point	10472.3	4.02004
48 29 17	228 26 35	Sherwood.	7631.3	3.88260
259 55 33	79 58 48	Old Farms	6995.2	3.84480
342 56 54	162 57 27	Sherwood.	4016.2	3.60381
244 16 15	64 21 24	Brushy Ridge	12168.6	4.08524
324 06 11	144 07 59	Palmer.	6565.8	3.81729
63 34 10	243 30 52	Palmer	7875.5	3.89628
180 36 53	0 36 55	Brushy Ridge.	7086.1	3.85041
315 01 49	135 03 33	Lockwood	5235.9	3.71899
228 08 35	48 10 21	Brushy Ridge.	5066.5	3.70471
359 11 08	179 11 10	Palmer	5989.5	3.77739
81 39 54	261 35 44	Round Hill.	8866.3	3.94774
142 57 02	322 54 51	Brushy Ridge	7712.4	3.88719
161 26 39	341 24 41	Bald Hill (Fairfield County).	13182.6	4.12000

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
St. John.	41 06 58.31	1798.7	73 25 31.86	743.3
Handford.	41 09 06.74	207.9	73 22 27.02	630.1
Saugatuck.	41 07 28.00	863.7	73 19 23.08	538.4
Hubbel (Uriah).	41 10 17.32	534.3	73 15 37.07	864.1
Gould.	41 10 58.50	1804.6	73 16 38.38	894.5
Pine Creek Point. 1833.	41 07 06.34	195.6	73 15 42.24	985.5
Thorp.	41 07 59.10	1823.1	73 19 09.00	209.9
Mill Hill.	41 08 49.37	1523.0	73 16 42.32	986.5
Adams.	41 09 03.40	104.9	73 19 36.48	850.7
Hubbel (Levi).	41 08 42.10	1298.7	73 20 20.36	474.8
Frost Point.	41 06 55.52	1712.7	73 18 34.71	809.8
Beach Point.	41 07 41.46	1279.0	73 14 33.38	545.4
Bradley (Fairfield County).	41 10 53.83	1660.6	73 17 30.54	711.8
Johnson.	41 10 04.88	150.6	73 10 04.08	95.1
Nichols.	41 08 49.10	1514.7	73 08 10.72	250.0
Brown.	41 10 01.82	56.2	73 25 47.64	1110.6
Cockenoe's Island.	41 05 01.42	43.8	73 21 20.76	484.5
Greenfield church spire. 1833.	41 10 37.06	1143.2	73 17 34.21	797.4
Fairfield Presbyterian church spire. 1833.	41 08 35.99	1110.3	73 15 01.57	36.6
Bridgeport north steeple. 1833.	41 10 37.64	1161.1	73 11 26.53	618.4
Bridgeport middle steeple. 1833.	41 10 34.76	1072.3	73 11 24.83	578.8
Bridgeport south steeple. 1833.	41 10 32.51	1002.9	73 11 23.95	558.3
Southport unfinished steeple. 1833.	41 08 07.14	220.2	73 16 54.70	1275.8

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
132 44 38	312 42 22	Brushy Ridge	6637.1	3.82198
198 20 20	18 21 30	Gorham.	7865.0	3.89570
152 22 16	332 21 24	Gorham	3953.5	3.59698
200 27 23	20 29 01	Merwin.	9955.9	3.99808
36 59 24	216 56 51	Copp's Island	9019.7	3.95519
127 22 43	307 16 36	Bald Hill (Fairfield County).	16375.7	4.21420
194 45 49	14 46 42	Chestnut	7535.1	3.87709
221 57 18	41 58 46	Sherwood.	4635.1	3.66606
244 18 40	64 20 48	Sherwood	5023.8	3.70103
311 37 32	131 38 12	Hubbel (Uriah).	1911.9	3.28146
169 38 50	349 38 13	Gould	7280.6	3.86217
199 01 12	19 02 43	Sherwood.	9878.5	3.99469
212 22 59	32 24 38	Gould	6555.1	3.81658
288 37 52	108 40 08	Pine Creek Point.	5090.3	3.70674
181 19 20	1 19 23	Gould	3984.2	3.60034
209 16 23	29 17 06	Hubbel (Uriah).	3110.8	3.49287
276 04 03	96 05 58	Mill Hill	4083.9	3.61107
342 05 27	162 05 45	Thorp.	2085.1	3.31912
237 16 06	57 16 35	Adams	1216.1	3.08497
308 33 05	128 33 52	Thorp.	2128.3	3.32804
157 49 12	337 48 49	Thorp	2117.9	3.32590
265 14 17	85 16 10	Pine Creek Point.	4037.5	3.60611
55 59 40	235 58 55	Pine Creek Point	1937.5	3.28724
156 01 17	336 00 37	Fairfield.	3460.5	3.53914
263 14 50	83 15 24	Gould	1224.6	3.08799
293 03 07	113 04 22	Hubbel (Uriah).	2874.5	3.45856
56 43 15	236 41 21	Black Rock	4830.3	3.68397
129 25 34	309 23 22	Sherwood.	6032.8	3.78052
95 58 44	275 53 53	Fairfield	10385.1	4.01641
139 45 30	319 41 30	Chestnut.	13116.6	4.11782
237 35 32	57 36 52	Gorham	3366.6	3.52719
311 26 08	131 29 17	Cumpo.	8935.1	3.95110
44 56 50	224 55 35	Copp's Island	3791.8	3.57885
188 01 12	8 01 25	Cumpo.	3384.2	3.52946
248 15 22	68 20 54	Stratford Hill	12623.2	4.10117
278 07 57	98 14 50	Stratford Point.	14794.8	4.17011
152 49 58	332 48 54	Gould	4940.6	3.69378
268 11 12	88 12 34	Black Rock.	2900.4	3.46245
214 12 34	34 14 04	Stratford Hill	5623.7	3.75002
289 16 37	109 19 28	Stratford Point.	6432.5	3.80838
213 22 31	33 23 59	Stratford Hill	5675.1	3.75397
288 38 39	108 41 29	Stratford Point.	6366.2	3.80388
212 49 16	32 50 44	Stratford Hill	5722.2	3.75756
288 06 19	108 09 09	Stratford Point.	6324.8	3.80105
46 36 03	226 31 52	Copp's Island	12237.1	4.08768
98 04 01	277 56 03	Brushy Ridge.	17101.7	4.23304

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Scofield.	41 08 20.92	645.4	73 34 52.98	1235.5
Jackson.	41 15 06.59	203.3	73 17 00.41	9.5
Goodsall.	41 15 58.50	1804.6	73 24 55.52	1292.5
Bridgeport Harbor L. H. 1853.	41 09 26.26	810.1	73 10 48.40	1128.4
Greenwich Point.	41 00 09.90	305.4	73 34 17.40	406.6
Long Neck.	41 02 11.10	342.4	73 28 40.88	955.0
Sheffield Island.	41 02 50.20	1548.6	73 25 21.73	507.5
Noroton Point.	41 03 19.32	596.0	73 26 19.40	453.0
Fish Island.	41 02 54.35	1676.6	73 27 28.32	661.4
Shippan Point.	41 01 12.22	377.0	73 31 24.38	569.6
Tavern Island.	41 03 39.14	1207.4	73 25 20.80	485.7
Great Captain's Island L. H. 1834.	40 58 57.18	1763.9	73 37 26.50	619.4
Calfpasture Island.	41 04 56.36	1738.6	73 23 03.57	83.3
Ram Island.	41 03 32.83	1012.7	73 24 12.52	292.3
Chimon's Island. 1834.	41 04 03.24	99.9	73 23 29.30	684.1
Close.	41 04 47.84	1475.8	73 38 03.75	87.5
Hobby.	41 03 35.28	1088.4	73 36 59.41	1387.3
Norwalk Islands L. H. 1834.	41 02 55.43	1709.9	73 25 10.52	245.6
West Rocks.	41 08 06.78	209.2	73 24 55.06	1284.2
Norfield spire. 1834.	41 12 10.31	318.0	73 22 40.51	943.9
New Canaan painted spire. 1834.	41 08 54.96	1695.4	73 29 46.02	1073.1
Benedict.	41 04 24.94	769.3	73 28 23.74	554.2
Green Farms spire. 1834.	41 08 09.62	296.8	73 19 50.77	1184.2

HOUSATONIC RIVER TO NEW YORK STATE LINE—*Continued.*

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
329 09 36	149 12 14	Noroton	10925.5	4.03844
39 40 11	219 38 53	Stanwich.	4312.5	3.63473
3 29 54	183 29 43	Pavement	6467.9	3.81076
66 44 41	246 42 44	Merwin.	4491.2	3.65236
42 09 51	222 07 22	Bald Hill (Fairfield County)	7848.9	3.89481
133 46 08	313 42 50	Loaf Hill.	9646.5	3.98437
62 23 05	242 21 36	Black Rock L. H.	3571.5	3.55285
157 55 29	337 55 06	Bridgeport, south steeple.	2205.2	3.34344
142 33 14	322 27 12	Round Hill	14127.7	4.15007
203 20 08	23 23 36	Brushy Ridge.	18629.9	4.27021
114 28 12	294 20 29	Round Hill	18072.6	4.25702
175 03 29	355 03 14	Lockwood.	6301.4	3.79944
75 28 56	255 26 45	Long Neck	4805.6	3.68175
134 20 42	314 18 16	Lockwood.	7258.7	3.86086
303 41 52	123 42 30	Sheffield Island	1619.1	3.20927
57 31 13	237 29 40	Long Neck.	3918.0	3.59306
244 24 48	64 25 33	Noroton Point	1784.1	3.25143
272 28 07	92 29 30	Sheffield Island.	2959.2	3.47118
64 35 18	244 33 24	Greenwich Point	4476.5	3.65094
192 25 41	12 27 15	Brushy Ridge.	15545.0	4.19159
189 15 08	9 16 10	Gorham	13788.6	4.13952
225 52 02	45 54 53	Cumpo.	8461.0	3.92742
118 20 08	298 18 12	Port Chester	4680.4	3.67028
143 15 00	323 12 16	Purdy.	9740.9	3.98860
137 24 01	317 22 23	St. John	5111.3	3.70853
219 17 52	39 19 13	Cumpo.	4533.1	3.65640
216 21 28	36 23 34	Cumpo	7556.1	3.87830
267 53 38	87 54 15	Copp's Island.	1332.7	3.12474
213 59 58	34 01 36	Cumpo	6207.7	3.79293
340 02 57	160 03 06	Copp's Island.	946.1	2.97592
235 59 43	56 05 40	Brushy Ridge	15268.3	4.18379
290 24 31	110 27 07	Palmer.	5918.3	3.77220
182 01 55	2 02 00	Stanwich	5495.4	3.74000
267 32 46	87 34 40	Palmer.	4048.3	3.60727
187 31 51	7 32 47	Gorham	15087.6	4.17862
218 51 22	38 54 06	Cumpo.	9297.4	3.96836
196 48 37	16 49 23	Gorham	5591.8	3.74755
293 22 23	113 24 57	Cumpo.	5961.4	3.77535
35 06 58	215 06 15	Gorham	2640.2	3.42165
98 17 02	278 13 04	Bald Hill (Fairfield County).	8502.6	3.92955
245 15 03	65 19 00	Gorham	9247.8	3.96604
312 36 45	132 39 26	Nash.	7750.0	3.88930
223 43 24	43 47 18	Handford	12034.8	4.08044
246 33 38	66 38 30	Cumpo.	11271.2	4.05197
33 32 43	213 31 57	Cumpo	2944.8	3.46906
64 49 56	244 46 05	Nash.	9045.4	3.95643

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Horseneck spire. 1833.	41 02 06.08	187.6	73 37 24.46	571.4
Moose Hill East.	41 24 05.57	171.8	73 06 55.36	1286.0
Blackburn.	41 21 35.34	1090.2	73 11 43.14	1002.8
Whitehill church. 1839.	41 20 02.80	86.4	73 08 52.37	1217.8
Rockhouse Hill.	41 23 04.94	152.4	73 08 22.13	514.2
South Whitehill.	41 19 12.91	398.3	73 07 56.23	1307.9
South Whitehill, tree.	41 19 14.36	443.0	73 07 53.38	1241.6
Hawley.	41 19 17.46	538.6	73 14 55.50	1290.8
Trumbull.	41 17 46.94	1448.0	73 15 44.52	1035.8
Booth.	41 16 42.43	1308.9	73 11 06.28	146.2
Tashua church. 1839.	41 17 13.31	410.6	73 15 38.87	904.6
Monroe, tall spire. 1839.	41 19 58.84	1815.2	73 12 26.90	625.6
Monroe, belfry. 1839.	41 19 55.38	1708.4	73 12 24.48	569.3
Norwalk, north spire. 1834.	41 07 14.62	451.0	73 24 28.56	666.3
Norwalk, south spire. 1834.	41 07 07.66	236.3	73 24 30.78	718.1
Sheffield West.	41 02 52.01	1604.4	73 25 27.59	644.4
Peet Hill.	41 40 02.37	73.1	73 26 08.97	207.5
Hamlin, N. Y.	41 59 10.51	324.3	73 32 48.90	1125.5
Brace Mountain monument, N. Y.	42 02 39.91	1231.4	73 29 34.88	802.4
Spencer's Corner spire, N. Y. 1863.	41 57 45.62	1407.6	73 30 08.69	200.1
Wing monument stone, N. Y.	41 33 30.38	937.2	73 31 40.71	943.4
Warren Observatory, flag-staff. 1864.	41 43 37.45	1155.3	73 21 13.14	303.7
Cobble.	41 46 37.15	1146.2	73 30 04.53	104.6

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		Metres.	
256 33 30	76 37 47	Noroton	9397.2	3.97300
345 53 22	165 53 57	Little Captain's Island.	5125.3	3.70972
201 15 30	21 16 18	Chestnut Tree Hill	4666.5	3.66899
294 49 52	114 52 07	Peck.	5246.1	3.71984
223 03 23	43 05 58	Riggs	7974.1	3.90168
265 02 33	85 05 39	Great Hill East.	6573.7	3.81781
46 26 12	226 22 09	Tashua	11853.3	4.07384
100 56 27	280 51 25	Pine Swamp Hill.	10816.3	4.03408
194 13 13	14 13 35	Riggs	3157.5	3.49934
319 30 26	139 31 19	Great Hill East.	2890.9	3.46103
56 11 14	236 06 34	Tashua	11910.8	4.07594
89 39 41	269 36 56	Moose Hill.	5811.5	3.76429
225 54 28	45 59 38	Hooper	15178.9	4.18124
235 25 11	55 30 14	Hickox 2.	12971.2	4.11298
272 33 26	92 35 18	Moose Hill	3944.0	3.59594
1 08 53	181 08 49	Tashua.	6776.6	3.83101
242 44 32	62 46 56	Moose Hill	5714.9	3.75701
345 49 51	165 50 19	Tashua.	4107.3	3.61356
70 00 36	249 58 01	Tashua	5822.6	3.76512
223 35 20	43 37 25	South Whitehill.	6411.1	3.80693
343 28 16	163 28 41	Tashua	3071.8	3.48740
56 48 18	236 45 38	Wheeler.	6747.6	3.82915
24 03 48	204 02 06	Tashua	8816.6	3.94530
83 04 51	262 57 54	Center Redding.	14784.3	4.16980
24 41 14	204 39 30	Tashua	8743.0	3.94166
83 31 03	263 24 04	Center Redding.	14828.3	4.17109
38 21 18	218 20 30	Nash	2747.3	3.43890
71 13 02	251 12 20	St. John.	1559.3	3.19294
40 26 28	220 25 40	Nash	2548.5	3.40628
78 36 02	258 35 22	St. John.	1453.2	3.16234
106 34 04	286 24 14	Round Hill	21867.5	4.33980
166 13 30	346 11 22	Bald Hill (Fairfield County).	18990.7	4.27854
257 48 36	77 55 04	Mount Tom	13803.0	4.13997
311 54 52	132 01 52	Good.	19690.5	4.29426
295 18 37	115 31 33	Ivy	29616.0	4.47153
12 14 04	192 13 11	Haines.	8611.1	3.93506
308 58 39	129 02 59	Prospect Hill	11508.2	4.06101
22 56 37	202 53 35	Haines.	16151.5	4.20821
43 35 43	223 33 03	Haines	8000.9	3.90314
125 23 32	305 21 45	Hamlin.	4523.9	3.65551
234 37 29	54 47 37	Mount Tom	25955.1	4.41422
272 40 02	92 50 42	Good.	22365.6	4.34958
338 30 29	158 34 13	Good	21279.6	4.32796
82 14 45	262 08 11	Preston.	13794.7	4.13971
87 57 52	267 53 04	Plymouth	10001.2	4.00005
159 16 07	339 13 24	Haines.	15856.5	4.20021

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Sarah Bishop, N. Y.	41 18 12.90	398.0	73 33 16.65	387.3
Iron bolt, Mass.	42 02 58.67	1810.2	73 29 42.62	980.1
Easton spire. 1839.	41 15 01.63	50.3	73 18 10.59	246.5
Dead tree Hill.	41 17 13.17	406.3	73 18 59.50	1384.7
Redding Ridge.	41 18 11.10	342.4	73 21 12.32	286.7
Redding spire. 1839.	41 18 49.68	1532.6	73 21 04.34	100.8
Ridgefield Presbyterian church. 1839.	41 16 30.47	940.0	73 29 52.89	1231.0
Crouch.	41 17 08.85	273.0	73 25 56.32	1310.7
Picket's Ridge.	41 19 29.41	907.3	73 27 11.43	265.8
Baker.	41 18 29.29	903.6	73 31 20.28	471.8
Patrick.	41 17 36.24	1118.0	73 31 18.62	433.3
Osborne (Fairfield County).	41 23 37.47	1155.9	73 12 44.87	1042.4
Stamford northeast spire. 1834.	41 03 14.76	455.3	73 32 03.19	74.5
Stamford southwest spire. 1834.	41 03 12.78	394.2	73 32 21.98	513.3
Ryant Bush, Mass.	42 03 04.05	125.0	73 28 56.63	1302.3
Ball Peak (Mount Riga).	42 00 43.33	1336.9	73 27 57.84	1330.8
Hitchcock.	41 48 04.49	138.5	73 29 42.13	972.6
Lambert.	41 48 10.94	337.5	73 30 13.25	305.8
Connecticut.	41 57 28.35	874.7	73 29 37.59	865.6
Chapel's Lot, N. Y.	41 43 08.30	256.1	73 31 07.20	166.4
Clark's monument, N. Y.	41 48 02.69	83.0	73 30 27.96	645.5
Iron bolt, near 30-mile boundary stone, N. Y.	41 43 08.36	257.9	73 30 51.65	1194.0
Bancroft, N. Y.	41 33 41.11	1268.2	73 31 42.69	989.1

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
194 28 23	14 28 30	Bailey	984.3	2.99314
116 06 00	295 59 24	Watermelon.	15521.4	4.19093
310 35 10	130 39 35	Prospect Hill	12015.5	4.07974
21 35 58	201 33 00	Haines.	16619.8	4.22063
74 35 50	254 28 54	Bald Hill (Fairfield County)	15249.7	4.18326
117 15 47	297 08 02	Loaf Hill.	18430.6	4.26554
297 55 30	117 58 07	Tashua	6275.1	3.79762
14 47 49	194 47 21	Wheeler	3818.9	3.58194
298 40 18	118 44 22	Tashua	9843.3	3.99314
46 35 28	226 30 31	Bald Hill (Fairfield County).	14409.9	4.15866
304 58 53	125 02 52	Tashua	10314.1	4.01343
43 50 43	223 45 41	Bald Hill (Fairfield County).	15380.1	4.18696
278 04 55	98 08 11	Goodsall	6991.3	3.84456
346 18 08	166 18 55	Bald Hill (Fairfield County).	7004.9	3.84540
76 49 24	256 46 38	High Ridge	6032.3	3.78048
129 04 54	309 02 17	Loaf Hill.	7140.4	3.85372
35 53 43	215 51 46	High Ridge	7051.5	3.84828
92 28 17	272 26 29	Loaf Hill.	3808.9	3.58080
224 28 52	44 29 48	Loaf Hill	2828.7	3.45158
336 45 05	156 45 52	High Ridge.	4199.7	3.62322
288 38 51	108 43 03	Goodsall	9412.0	3.97368
337 31 03	157 32 47	Bald Hill (Fairfield County).	9560.0	3.98046
253 19 20	73 22 36	Riggs	7179.3	3.85608
291 49 46	111 53 33	Great Hill East.	8600.8	3.93454
105 41 27	285 40 06	Palmer.	2984.1	3.47481
132 22 40	312 19 31	Stanwich.	9091.2	3.95862
134 35 34	314 32 37	Stanwich	8816.4	3.94529
202 14 44	22 16 56	Brushy Ridge.	12384.0	4.09286
314 42 34	134 46 28	Prospect Hill	11349.8	4.05499
24 41 02	204 37 34	Haines.	17188.3	4.23523
298 29 53	118 33 08	Prospect Hill	7637.8	3.88297
37 07 10	217 03 03	Haines.	14139.4	4.15043
153 12 12	333 09 15	Haines	13595.4	4.13339
268 18 17	88 19 57	Ellsworth.	3456.6	3.53865
356 01 15	176 01 21	Cobble	2900.8	3.46252
71 38 42	251 33 59	Plymouth.	10318.2	4.01361
49 50 15	229 47 14	Haines	8156.8	3.91152
125 36 30	305 34 22	Hamlin.	5416.3	3.73370
356 09 10	176 09 12	Preston	977.2	2.98998
76 57 00	256 50 02	Clove.	14929.0	4.17403
267 00 43	87 01 14	Hitchcock	1059.6	3.02515
233 07 52	53 08 02	Lambert.	424.4	2.62777
89 43 22	269 43 12	Chapel's Lot	359.5	2.55571
16 45 05	196 44 57	Preston.	1020.0	3.00861
141 58 55	321 55 02	Clark	13189.3	4.12022
159 55 21	339 54 50	Osborne.	3146.4	3.49781

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Station.	Latitude.	Seconds in metres.	Longitude.	Seconds in metres.
	° ′ ″		° ′ ″	
Briggs, N. Y.	41 34 35.88	1106.9	73 31 49.10	1137.4
Corner Stone, N. Y.	42 02 58.38	1801.2	73 29 15.96	367.0
Connecticut Line (Borden).	42 02 58.78	1813.6	73 29 42.92	986.9
Monument stone, N. Y.	41 34 24.64	760.2	73 31 35.87	831.1
Goshen Center Congregational church. 1865.	41 49 54.11	1669.5	73 13 30.74	709.2
Preston, white spire. 1865.	41 41 05.78	178.4	73 18 42.98	994.1
Preston, stone church. 1865.	41 40 37.16	1146.3	73 22 22.82	527.8
Litchfield, Congregational church. 1865.	41 44 52.26	1612.3	73 11 18.49	427.2
Litchfield, Episcopal church. 1865.	41 44 46.21	1425.6	73 11 19.29	445.6
Hunt.	41 18 24.28	749.1	73 32 54.32	1263.7
Mead. 1864.	41 18 07.34	226.4	73 32 53.13	1236.0
Ridgefield Angle monument stone, N. Y.	41 17 42.68	1316.7	73 33 06.79	158.0
Ridgefield Episcopal church. 1865.	41 16 49.50	1527.2	73 29 59.05	1374.1
Lewisborough Presbyterian church, N. Y. 1865.	41 16 24.03	741.4	73 33 17.57	408.9
Round Mountain monument, N. Y.	41 25 11.91	367.4	73 32 20.53	476.8
Danbury Congregational church. 1864.	41 23 39.87	1230.0	73 27 11.87	275.8
Wilton monument, N. Y.	41 12 46.07	1421.3	73 28 56.40	1313.8
Connecticut monument.	41 57 30.00	925.4	73 29 37.56	865.0
Coram.	41 17 52.72	1626.4	73 05 04.11	95.6
Star.	41 18 46.66	1439.4	73 27 39.18	911.3
Ruined church spire near Bridgeport. 1833.	41 10 59.80	1844.7	73 12 26.50	617.6
Tashua tree.	41 15 38.50	1187.7	73 15 01.08	25.1

HOUSATONIC RIVER TO NEW YORK STATE LINE—Continued.

Azimuth.	Back azimuth.	To stations.	Distance.	Logarithms.
° ′ ″	° ′ ″		*Metres.*	
354 58 41	174 58 45	Bancroft	1696.3	3.22951
143 38 03	323 37 37	Osborne.	1571.3	3.19626
37 22 17	217 22 04	Brace Mountain monument	717.0	2.85553
336 39 53	156 40 45	Ball Peak.	4537.5	3.65682
168 55 36	348 55 12	Alander Mountain	4284.5	3.63190
221 28 19	41 30 49	Bald Peak.	7765.5	3.89017
6 42 35	186 42 30	Bancroft	1352.2	3.13105
138 32 25	318 32 16	Briggs.	462.8	2.66539
14 45 01	194 43 05	Mount Tom	15876.3	4.20075
180 49 59	0 50 01	Ivy.	4455.5	3.64890
52 06 21	231 57 44	Wing monument stone	22837.8	4.35865
253 25 32	73 27 03	Mount Tom.	3316.2	3.52064
78 25 32	258 23 01	Peet Hill	5340.4	3.72757
257 29 23	77 33 21	Mount Tom.	8463.1	3.92753
53 28 11	233 14 39	Wing monument stone	35247.3	4.54713
49 37 21	229 33 57	Mount Tom.	9320.7	3.96945
53 41 47	233 28 15	Wing monument stone	35121.7	4.54558
50 26 05	230 22 41	Mount Tom.	9186.7	3.96316
55 57 53	235 57 38	Sarah Bishop	627.1	2.79732
155 33 49	335 33 41	Bailey.	661.3	2.82042
107 23 54	287 23 38	Sarah Bishop	573.5	2.75852
176 58 37	356 58 36	Hunt.	523.2	2.71865
166 10 40	346 10 34	Sarah Bishop	960.2	2.98237
202 40 11	22 40 20	Mead.	824.7	2.91628
119 14 57	299 12 47	Sarah Bishop	5268.8	3.72171
346 17 56	166 18 47	Bald Hill (Fairfield County).	7609.2	3.88134
180 21 51	0 21 52	Sarah Bishop	3358.5	3.52615
190 06 58	10 07 14	Mead.	3237.3	3.51019
34 46 09	214 46 05	Round Mountain	208.5	2.31907
5 03 22	185 02 52	Bailey.	12020.3	4.07991
110 08 19	290 04 52	Round Mountain	7761.1	3.88993
31 23 59	211 22 35	Wooster.	5633.6	3.75079
251 09 47	71 09 56	Bald Hill (Fairfield County)	362.2	2.55891
254 40 51	74 50 01	Tashua.	20155.8	4.30440
1 06 30	181 06 30	Connecticut	51.0	1.70759
125 09 41	305 07 33	Hamlin.	5387.5	3.73139
327 02 34	147 05 05	Milford	9788.1	3.99070
32 40 14	212 39 33	Bennet.	2660.4	3.42494
115 08 17	295 06 47	Loaf Hill	3490.3	3.54286
266 12 36	86 15 41	Center Redding.	6556.6	3.81668
55 53 04	235 51 01	Fairfield	5271.4	3.72193
147 52 24	327 51 46	Sherwood.	2522.0	3.40174
260 42 54	80 53 52	Allen	23509.9	4.37125
269 57 48	90 08 29	Jones.	23169.7	4.36492

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Appendix No. 9.—1888.

TIDAL LEVELS AND FLOW OF CURRENTS IN NEW YORK BAY AND HARBOR.

Report by HENRY L. MARINDIN, Assistant.

U. S. Coast and Geodetic Survey Office,
Washington, *May* 15, 1888.

Sir: In the twelve sketches accompanying this paper, the attempt has been made to demonstrate graphically the movements of the tide in filling and draining the tidal reservoirs surrounding New York City. This project was rendered practicable by the extensive tide observations made in 1886 by the party of physical hydrography in my charge, and by the completion of the lines of precise levels joining the tide stations, which were begun in 1886 and finished in 1887 by the parties in charge of Assistant J. B. Weir, and Subassistant J. E. McGrath.

The sketches (illustrations Nos. 27 to 38 inclusive) represent vertical cross-sections of the height of the tide above or below the line of mean sea-level for each lunar hour after the moon's transit, so that each sketch gives the state of the tide at intervals of about 62 minutes of civil time (12 of these intervals complete a revolution of the tide).

The data shown on the sketches were obtained directly from the observations made at the tide stations. The reading of mean sea-level at Sandy Hook, which is taken as the datum line, was first computed for each tide-staff observed simultaneously, and after grouping the readings of the staff for 24 lunar hours, a mean difference in the height of the tide was obtained which eliminated the diurnal inequality for that day. This mean height, corrected for a mean tide, is the quotation represented in the vertical sections.

The datum line (mean sea-level) is represented by a broken line joining the points where the tide-staffs were located, and the surface of the water either above or below this plane is indicated by a full line. The shading of the vertical section is given in full lines (darker tone) above, and in broken lines (lighter tone) below mean sea-level, so as to convey to the eye without effort the stage of tide at that time.

The readings of mean sea-level as derived from the tide observations were compared with those obtained from the precise leveling, and it was gratifying to find such a close agreement as not to affect the result already obtained.

The plus sign indicates above, and the minus sign below, mean sea-level. The quotation of the height is expressed in feet and tenths at the places where the tide-staffs were located.

The general direction of the current is also indicated by an arrow with the velocity expressed in feet per second. The velocity given is that observed at the place and corrected for a mean tide corresponding to that represented in the vertical sections.

The following tables contain the final results from which the sketches were made:

NEW YORK BAY AND HARBOR.

Water-levels above and below mean sea-level at Sandy Hook.

[+ indicates above mean sea-level. — indicates below mean sea-level.]

Locality.	Lunar Hours.											
	O.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Sandy Hook.	−1.50	−1.80	−1.94	−1.37	−0.27	+0.92	+1.83	+2.14	+1.82	+1.05	+0.03	−0.79
Port Monmouth.	−1.45	−1.87	−1.97	−1.36	−0.10	+0.94	+1.77	+2.13	+1.83	+1.01	+0.03	−0.80
Conaskonk Point.	−1.55	−1.98	−2.06	−1.53	−0.15	+1.11	+1.77	+2.19	+1.93	+1.09	+0.02	−0.83
South Amboy.	−1.45	−1.96	−2.19	−1.77	−0.22	+0.95	+1.76	+2.30	+2.12	+1.22	+0.19	−0.75
Great Kills.	−1.56	−1.99	−2.14	−1.59	−0.15	+0.95	+2.02	+2.38	+2.13	+1.15	−0.02	−0.93
Locust Grove.	−1.49	−1.92	−1.97	−1.43	−0.10	+0.92	+1.73	+2.09	+1.86	+1.10	+0.09	−0.86
Quarantine Dock.	−1.40	−1.92	−1.99	−1.47	0.19	+0.80	+1.51	+1.88	+1.86	+1.30	+0.36	−0.73
Bay Ridge.	−1.35	−1.90	−2.07	−1.50	−0.33	+0.75	+1.50	+1.86	+1.94	+1.44	+0.52	−0.65
Constable Hook.	−1.25	−1.80	−2.03	−1.48	−0.40	+0.61	+1.40	+1.82	+1.98	+1.53	+0.56	−0.53
Hudson River, Forty-second street.	−1.03	−1.57	−1.92	−1.64	−0.62	+0.52	+1.23	+1.44	+1.67	+1.51	+0.84	−0.24
Governor's Island.	−1.17	−1.73	−2.05	−1.70	−0.47	+0.60	+1.30	+1.70	+1.90	+1.57	+0.66	−0.47
Corlears Hook.	−0.22	−0.74	−1.37	−1.95	−1.29	−0.50	+0.44	+1.02	+1.44	+1.81	+1.61	+0.54
Hunter's Point.	+0.18	−0.28	−1.17	−2.31	−1.92	−1.08	−0.35	+0.40	+1.05	+1.65	+1.64	+0.88
Ravenswood.	+0.60	+0.06	−0.93	−2.20	−2.14	−1.68	−1.15	−0.54	+0.50	+1.71	+1.95	+1.14
East River, Eighty-fourth street.	+1.22	+0.70	−0.56	−2.04	−2.28	−2.12	−1.83	−1.20	+0.25	+1.76	+2.31	+1.73
Pot Cove.	+2.55	+2.07	+0.45	−1.85	−2.59	−2.69	−2.73	−2.34	−0.62	+1.58	+2.62	+2.82
Polhemus Dock.	+2.67	+2.11	+0.35	−2.06	−2.92	−3.12	−3.21	−2.69	−0.74	+1.67	+2.70	+2.92
College Point.	+3.30	+2.63	+0.66	−1.92	−2.97	−3.27	−3.53	−2.89	−0.90	+1.92	+3.15	+3.43
Willets Point.	+3.46	+2.60	+0.65	−1.85	−3.13	−3.45	−3.55	−2.69	−0.50	+2.05	+3.45	+3.64
Elm Park.	−0.64	−1.37	−1.86	−1.85	−1.57	−0.54	+0.57	+1.40	+1.90	+1.93	+1.24	+0.24
Elizabethport.	−0.60	−1.34	−1.86	−2.02	−1.67	−0.53	+0.58	+1.37	+1.95	+1.98	+1.29	+0.32
Hackensack River Bridge.	−0.06	−0.78	−1.43	−1.96	−2.21	−1.23	−0.05	+1.04	+1.77	+2.02	+1.58	+0.73

Direction and velocity of currents.

[E.—East. W.—West. S.—South. N.—North. Surf.—Surface. Bot.—Bottom.]

Locality.	Lunar Hours.											
	O.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.
	Ft. p. sec.	*Ft. p. sec.*	*Ft. p. sec.*	*Ft. p. sec.*	*Ft. p. sec.*	*Ft. p. sec.*	*Ft. p. sec.*	*Ft. p. sec.*	*Ft. p. sec.*	*Ft. p. sec.*	*Ft. p. sec.*	*Ft. p. sec.*
Sandy Hook Bar.	S. 3.50	S. 2.35	S. 2.16	N. 0.30	N. 2.08	N. 2.54	N. 2.53	N. 2.50	N. 2.00	S. 1.98	S. 2.33	S. 3.48
The Narrows.	S. 3.20	S. 2.75	S. 2.20	Surf. S. 2.38 Bot. N. 1.01	Surf. S. 1.55 Bot. N. 1.20	N. 1.00	N. 2.20	N. 2.20	N. 2.10	N. 0.88	S. 0.81	S. 2.10
Kill van Kull.	E. 2.09	E. 1.74	E. 1.53	W. 0.61	W. 1.90	W. 3.07	W. 2.45	W. 2.11	Surf. E. 0.82 Bot. W. 0.10	E. 1.74	E. 2.32	E. 2.16
Hudson River, Forty second street.	S. 2.09	S. 4.84	S. 5.10	S. 4.09	Surf. S. 2.50 Bot. N. 1.08	Surf. S. 0.91 Bot. N. 1.91	N. 2.25	N. 3.67	N. 3.17	N. 2.33	N. 1.08	Surf. S. 0.74 Bot. N. 0.65
East River, Nineteenth street.	S. 4.14	S. 4.38	S. 2.64	S. 1.80	N. 2.98	N. 3.73	N. 3.88	N. 3.67	N. 2.99	N. 1.09	S. 3.60	S. 3.70
East River, Old Ferry Point.	W. 1.25	W. 0.96	Surf. E. 0.95 Bot. W. 0.55	E. 1.45	E. 1.75	E. 1.95	E. 2.38	E. 2.05	E. 1.10	W. 1.07	W. 1.90	W. 2.08

I give below a detailed description of the prominent features of the sketches.

0 *hour—Moon's transit.*—This sketch shows an ebb stage throughout the area represented. The Lower Bay, the Upper Harbor, the Kills with Newark Bay, and the western end of the East River are below mean sea-level. Only that part of the East River to the eastward of Fourteenth street, where the node is located, lies above the datum plane.

In the East River between Ravenswood and Pot Cove, the surface slope is very decided, the difference of level being 1.95 feet in that short distance.

The Hudson with the East River and Kill van Kull are pouring their waters into the Upper Harbor and out over Sandy Hook Bar.

First hour.—At this hour the waters are still ebbing over the entire area. Sandy Hook is now 1.80 feet below the datum plane; Governor's Island 1.73 feet below the same. The mean sea-level node has moved in the East River from Fourteenth street to Ravenswood, leaving the portion to the eastward of the node still above mean sea-level. The slope between Ravenswood and Pot Cove is slightly increased. The water-level is falling faster than previously; at Willets Point the fall has been 0.86 foot as against a fall of 0.18 foot between the XI and 0 hours. The Hudson River, Kill van Kull, and the East River are still discharging their waters into the Upper Harbor and through the Narrows over Sandy Hook Bar, with an increased velocity of current in the Hudson.

Second hour.—The surface of the Lower Bay, the Upper Harbor, Kill van Kull, Newark Bay, and the Hudson with the East River as far as Hell Gate, are all below the datum plane; at Sandy Hook 1.94 feet below, at Governor's Island 2.05 feet below. In the East River the node has worked slowly to the narrowest part of Hell Gate, all to the eastward remaining above the datum line, although the water at the entrance into Long Island Sound has been falling fast, equal to 1.95 feet since the first hour. All the streams are still discharging into the Upper Harbor; only that part of the East River east of College Point shows the stream flowing east at the surface, while the subcurrent is yet running towards the Upper Harbor.

In the Hudson the strength of the current has increased, but everywhere else the current velocity has diminished.

Third hour.—The entire water area is now found to lie below the datum plane. The tide is rising in the Lower Bay and Upper Harbor while it is falling in Newark Bay and the Kills. The surface of the East River throughout its length lies very nearly level, with a slight depression south of Hell Gate. The currents are now divided; to the westward of the Gate the current is southerly, while to the eastward it is flowing towards the Sound.

On Sandy Hook Bar the current is northward, very slight, and at the Narrows it is moving in that direction near the bottom, while the surface is running south still. In Kill van Kull the current has turned toward Newark Bay, but the Hudson and that part of the East River west of Hell Gate are yet discharging into the Upper Harbor.

Fourth hour.—The bays and streams are yet below the datum plane. At Sandy Hook the flood stream has filled up the Lower Bay till it is nearly at mean sea-level, being only 0.27 foot below that plane. The Hudson lies a little lower, while the Kills, Newark Bay, and the East River lie still lower.

While the Lower Bay and Harbor have been filling up with the flood stream from seaward, the East River, although receiving a full flood volume from the Upper Harbor, has continued to fall very fast, so that at Willets Point the surface lies 3.13 feet below the datum plane. The currents are more complicated at this hour; they are running northward from the sea over the Bar, and this direction is maintained as an under-current through the Narrows and up the Hudson, while the surface currents at these two places are flowing in the opposite direction.

Throughout the East River the stream is moving eastward towards Long Island Sound.

Fifth hour.—There is a change in the Lower Bay, the Upper Harbor, and in the Hudson, in that they now appear above the datum plane, while half of the Kills, with Newark Bay and nearly the whole of the East River, are yet below mean sea-level. Sandy Hook is 0.92 foot above datum plane, Governor's Island is 0.60 foot above; Newark Bay lies on an average 0.9 foot below, and the eastern end of the East River at Willets Point is 3.45 feet below datum. The currents are flood throughout with the exception of the surface stream in the Hudson which is still flowing south. The volume of water passing in at Sandy Hook is filling all the reservoirs and flowing through the ast River into Long Island S ound, which lies 4.37 feet below the level at Sandy Hook.

Sixth hour.—At this hour all the reservoirs with the exception of that portion of the East River east of Fourteenth street lie above the datum plane. It is the reversed counterpart of the conditions as they existed at 0 hour. In the East River the node is opposite Fourteenth street, the same point where it was at 0 hour, but with a reversed stage on either side of it.

Sandy Hook lies 1.83 feet above mean sea-level; Governor's Island 1.30 feet above, while at Willets Point the water surface is 3.53 feet below the datum plane.

All the currents are the reverse of what they were at 0 hour, and the Hudson is now flood from surface to bottom.

Seventh hour.—The reservoirs, with the exception of part of the East River, lie above mean sea-level. Sandy Hook is 2.14 feet above; Governor's Island 1.70 feet above, and Newark Bay averages 1.22 feet above.

The node in the East River has moved very slowly from off Fourteenth street to the southern end of Blackwell's Island; all that part to the eastward lies below the datum plane, and at Willets Point the water surface is 2.69 feet below, so that this point is now 4.83 feet below the water-level at Sandy Hook.

The currents are all northward and the western end of the sound is yet receiving a volume of water which has passed in at Sandy Hook.

Eighth hour.—Again this is the reversed condition which obtained at the second hour; the neutral point is at Hell Gate. Sandy Hook lies 1.82 feet above datum plane; Governor's Island 1.90 feet above, and the eastern end of Long Island Sound is 0.50 foot below mean sea-level. The currents also are reversed after substituting the condition at Kill van Kull for that at Old Ferry Point.

Ninth hour.—Reversed conditions of the third hour. All the basins are above datum plane. Sandy Hook is 1.05 feet above, Governor's Island 1.57 feet above, and Willets Point 2.05 feet above.

The current has turned to ebb on Sandy Hook Bar, but the stream in the Narrows is still north, with the Lower Hudson and western half of the East River flowing in the same direction. Newark Bay is discharging its waters into the Upper Harbor through Kill van Kull, and at the east end of the Sound the stream is flowing towards Hell Gate where a depression is apparent. The water surface is falling rapidly in the Upper Harbor and Lower Bay.

Tenth hour.—Reversed condition of the fourth hour as to height of tide; it is the restoration of mean sea-level in the Lower Bay on a falling tide as against the restoration of mean sea-level at the fourth hour on a rising tide. Sandy Hook is only 0.03 foot above datum plane, Governor's Island 0.66 foot above, and Willets Point 3.45 feet above.

The stream in Kill van Kull and in the East River is flowing towards the Upper Harbor, part of which volume passes out through the Narrows, but the Lower Hudson still presents a high velocity northward although resting at a higher level, and it is evident that much of the water from the East River finds its outlet up the Hudson when we consider the high velocity of 3.60 feet per second at Nineteenth street, with 1.08 feet in the Hudson and only 0.81 foot per second in the Narrows.

Eleventh hour.—This hour precedes the moon's transit or 0 hour.

The condition which obtains at this time is a complete reversal of that at the fifth hour. The Lower Bay and Upper Harbor lie below mean sea-level. Newark Bay, with adjacent parts of the Kills, lie above the datum plane and the East River largely above it.

The directions of the currents are also reversed and the Hudson exhibits the same feature of the surface current moving in one direction while the subcurrent flows in the opposite direction.

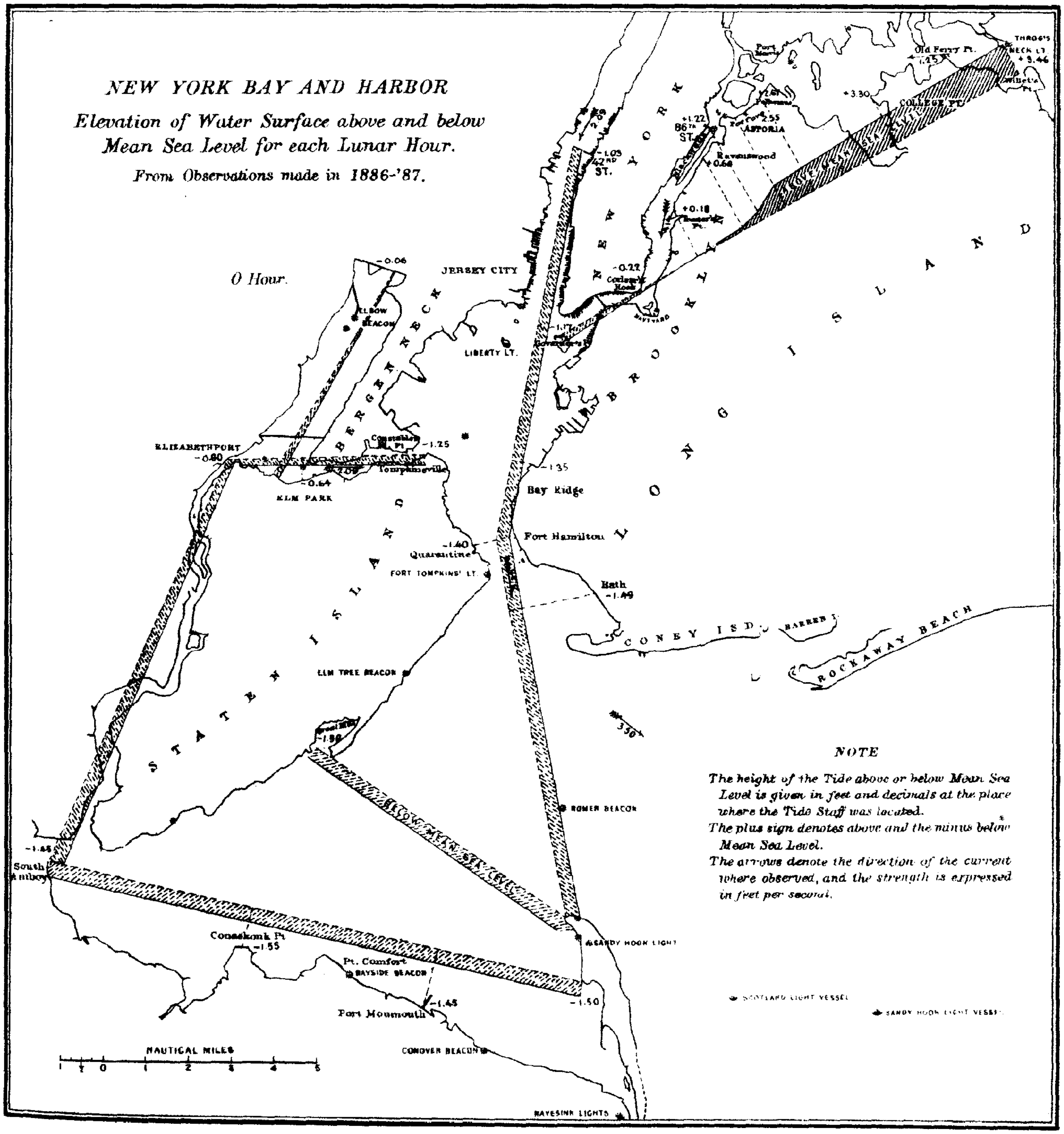
None of the sketches (drawn as they are to represent the stage of tide at the even hour) fall at the time of high or low water, but the stage of tide represented at the second hour is so near to the time of low water and that at the seventh hour so nearly the time of high water that they can be accepted as representing those phases.

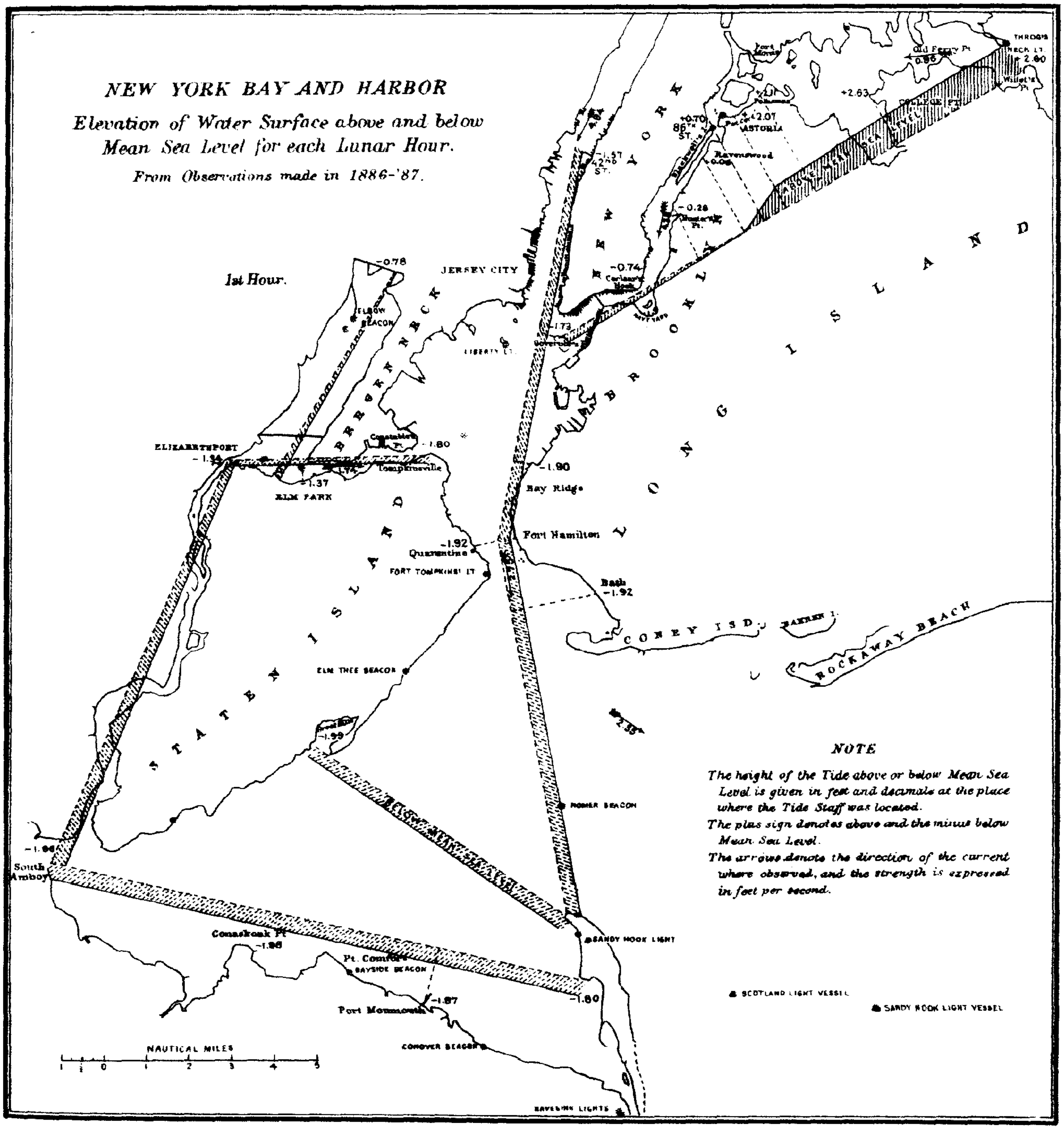
It is not possible to enumerate the questions which might be advanced or solved by the study of the data contained in these sketches. If they were no more valuable than in aiding the study of the question of the respective values of the bays and flats as tidal reservoirs in maintaining the channel ways through Sandy Hook Bar, they would then have repaid the time and labor spent in preparing them. They are offered as a progressive step in the study of the physical condition of the movements of the tides and currents which surround the principal commercial city of the United States.

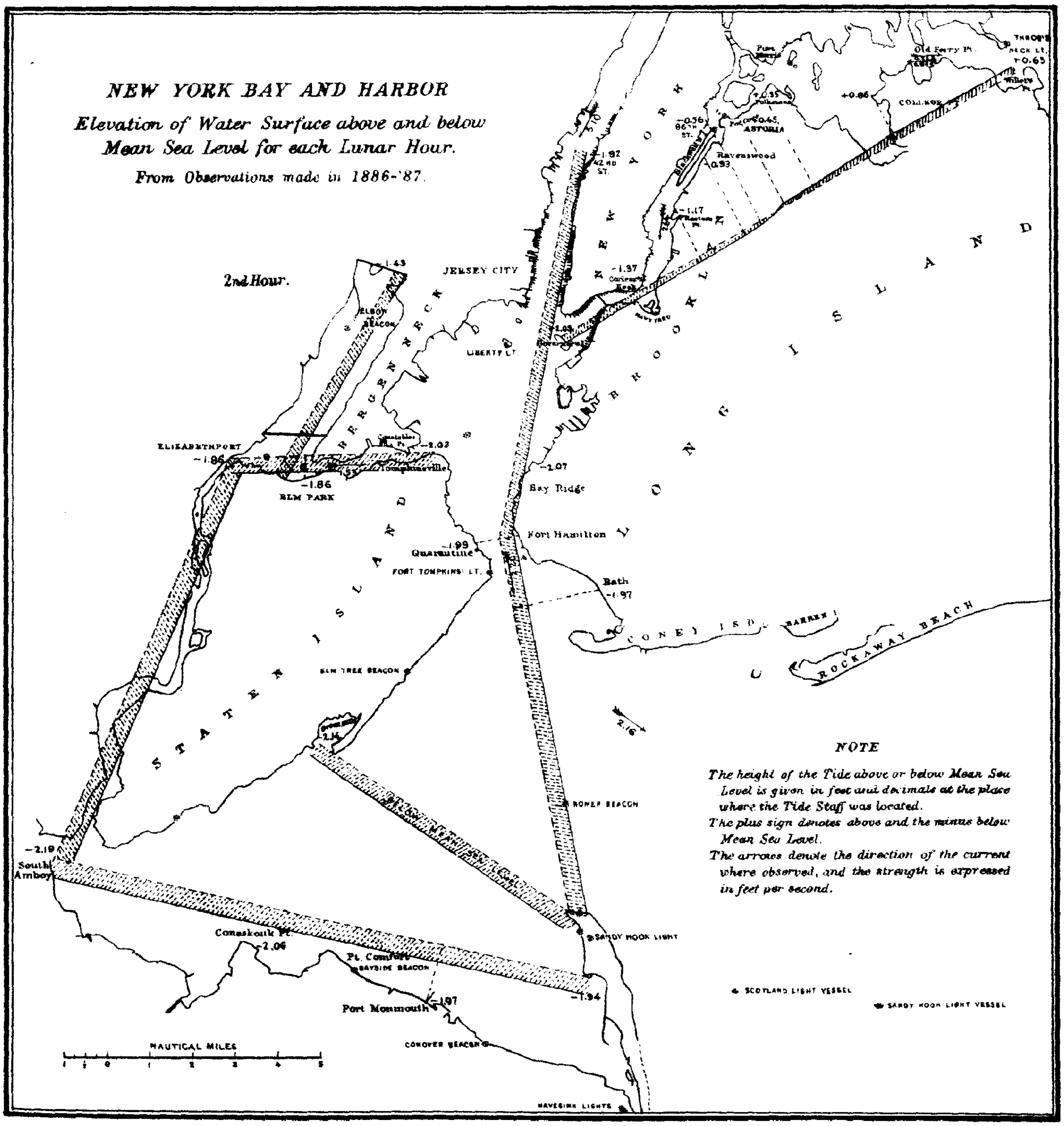
Very respectfully,

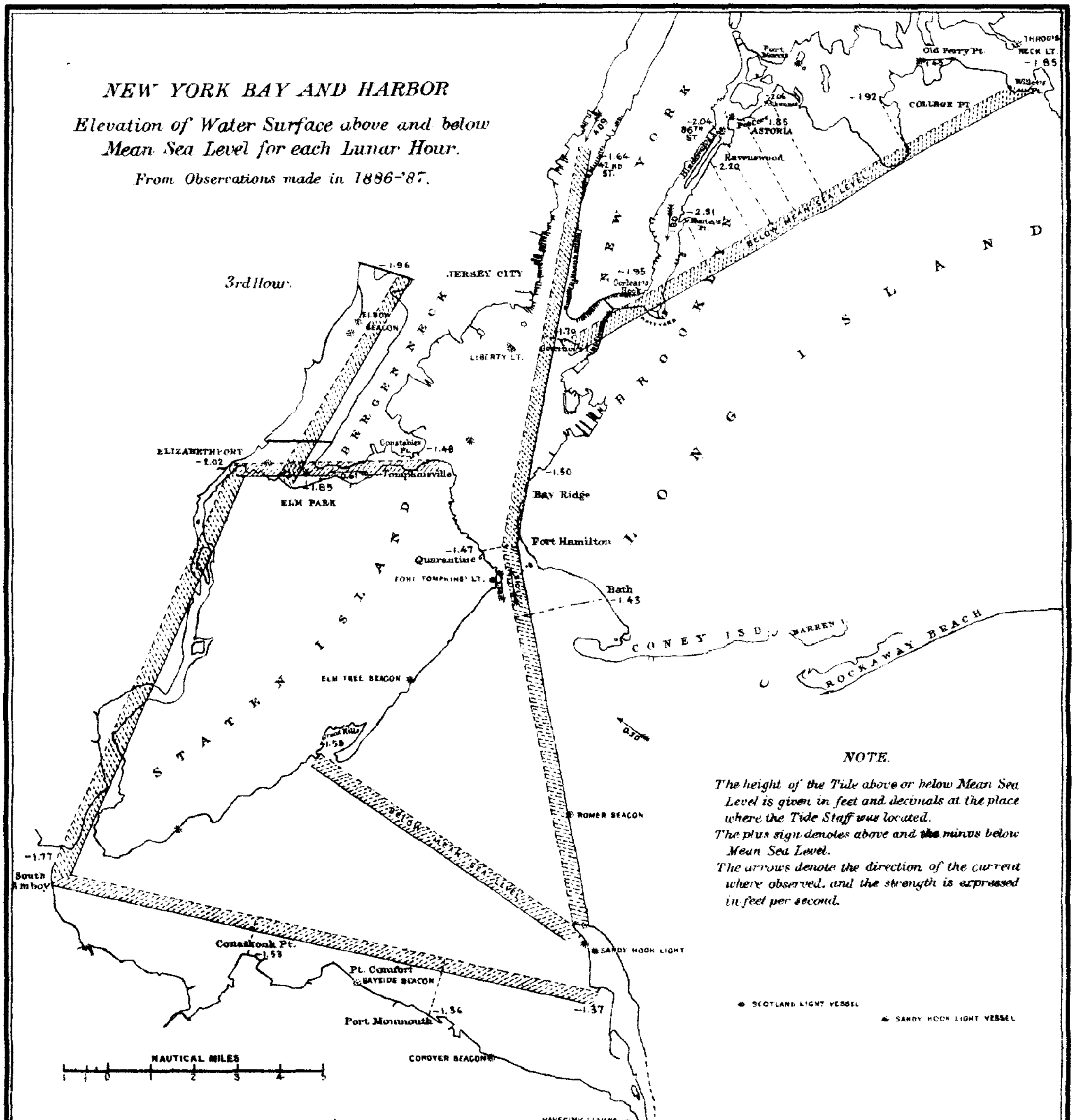
HENRY L. MARINDIN,
Assistant Coast and Geodetic Survey.

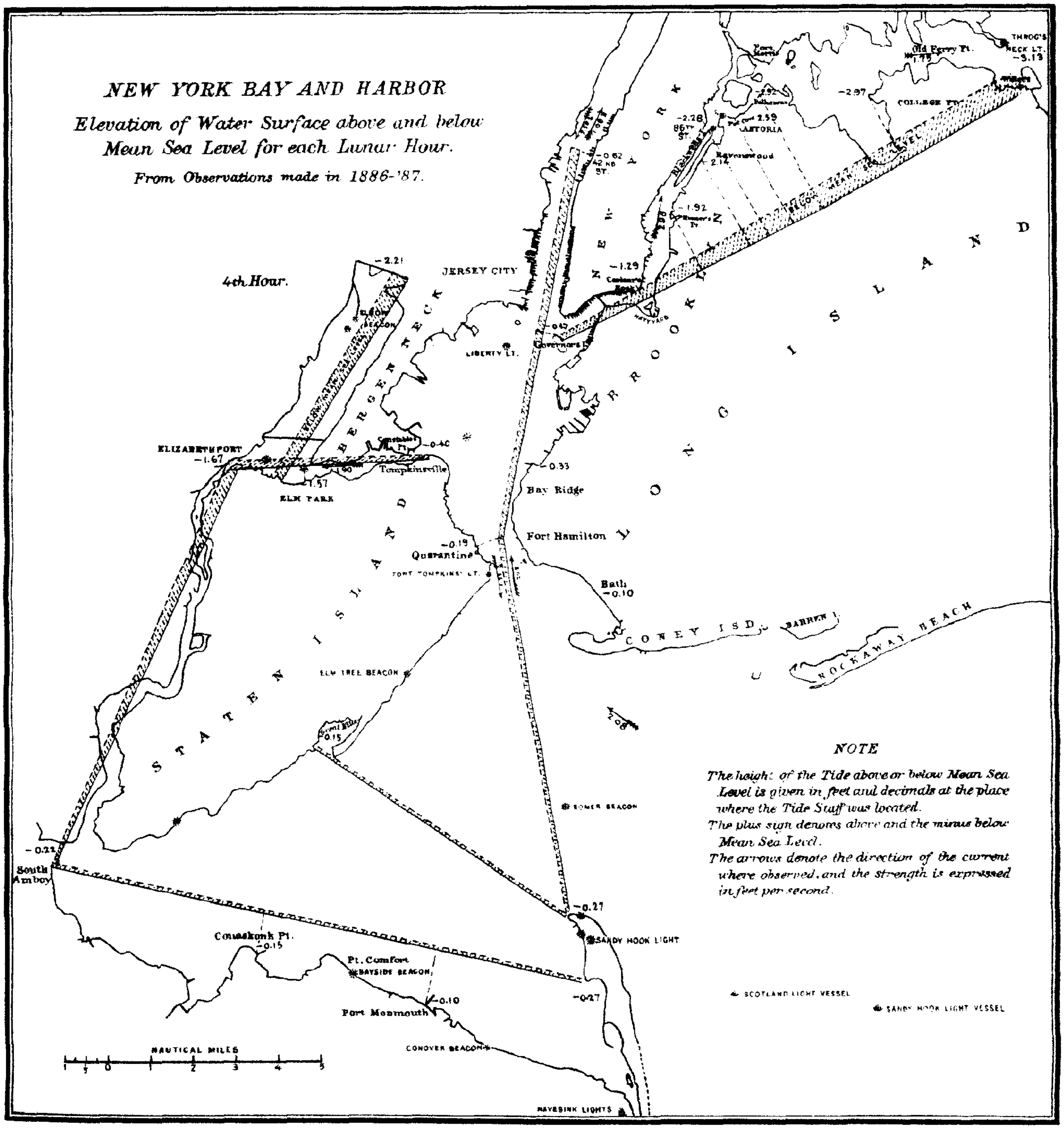
To the SUPERINTENDENT
COAST AND GEODETIC SURVEY.

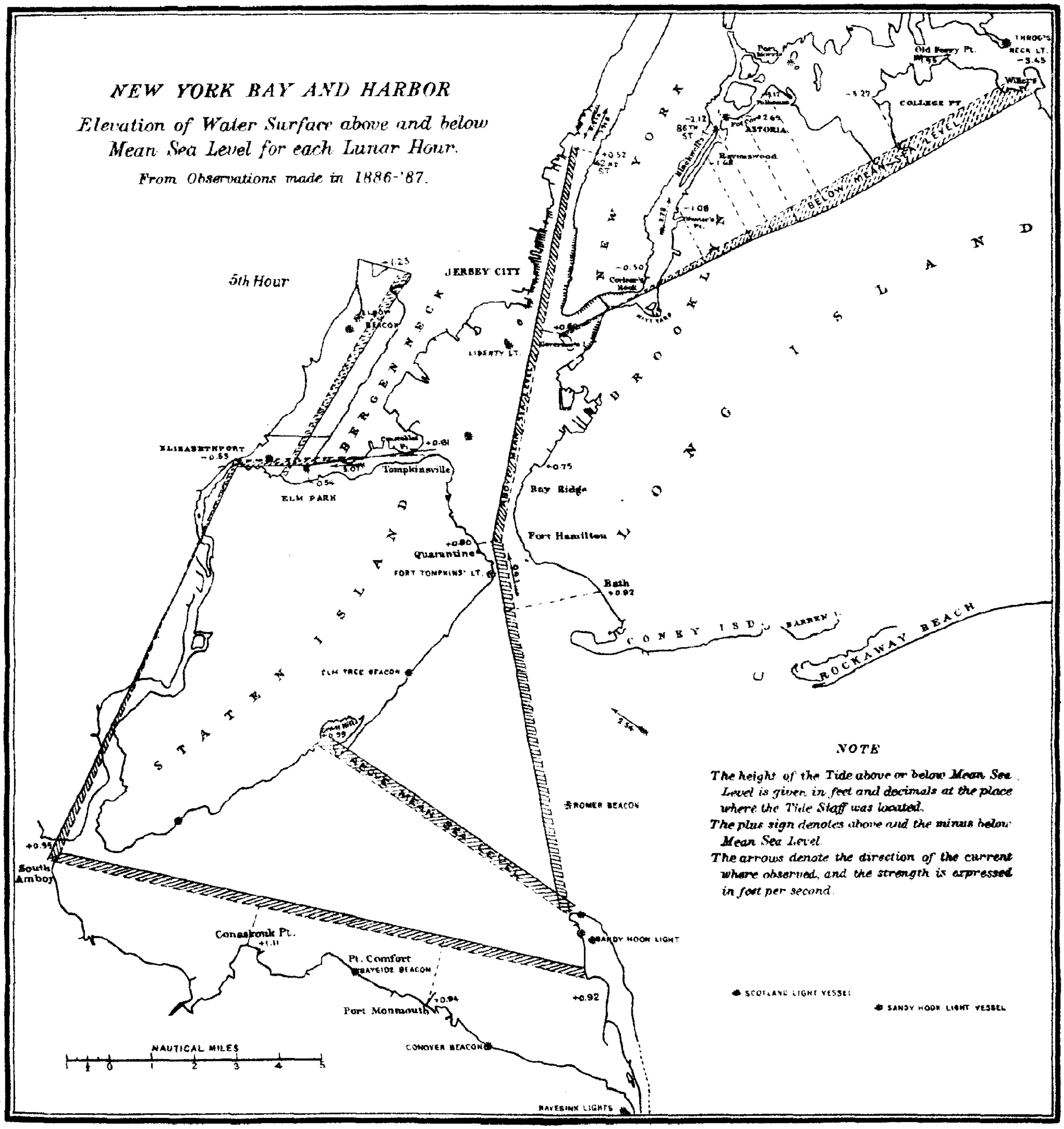

NEW YORK BAY AND HARBOR
Elevation of Water Surface above and below
Mean Sea Level for each Lunar Hour.
From Observations made in 1886-'87.
0 Hour.
NOTE
The height of the Tide above or below Mean Sea Level is given in feet and decimals at the place where the Tide Staff was located.
The plus sign denotes above and the minus below Mean Sea Level.
The arrows denote the direction of the current where observed, and the strength is expressed in feet per second.
NEW YORK
LONG ISLAND
BROOKLYN
STATEN ISLAND
BERGEN NECK
JERSEY CITY
LIBERTY LT.
ELIZABETHPORT
ELM PARK
Tompkinsville
Bay Ridge
Fort Hamilton
Quarantine
FORT TOMPKINS' LT.
Bath
CONEY ISD.
BARREN I.
ROCKAWAY BEACH
ELM TREE BEACON
ROMER BEACON
SANDY HOOK LIGHT
South Amboy
Conaskonk Pt.
Pt. Comfort
BAYSIDE BEACON
Fort Monmouth
CONOVER BEACON
NAVESINK LIGHTS
SCOTLAND LIGHT VESSEL
SANDY HOOK LIGHT VESSEL
ASTORIA
Ravenswood
COLLEGE PT.
Old Ferry Pt.
THROG'S NECK LT.
Willet's Pt.
NAUTICAL MILES
1 0 1 2 3 4 5

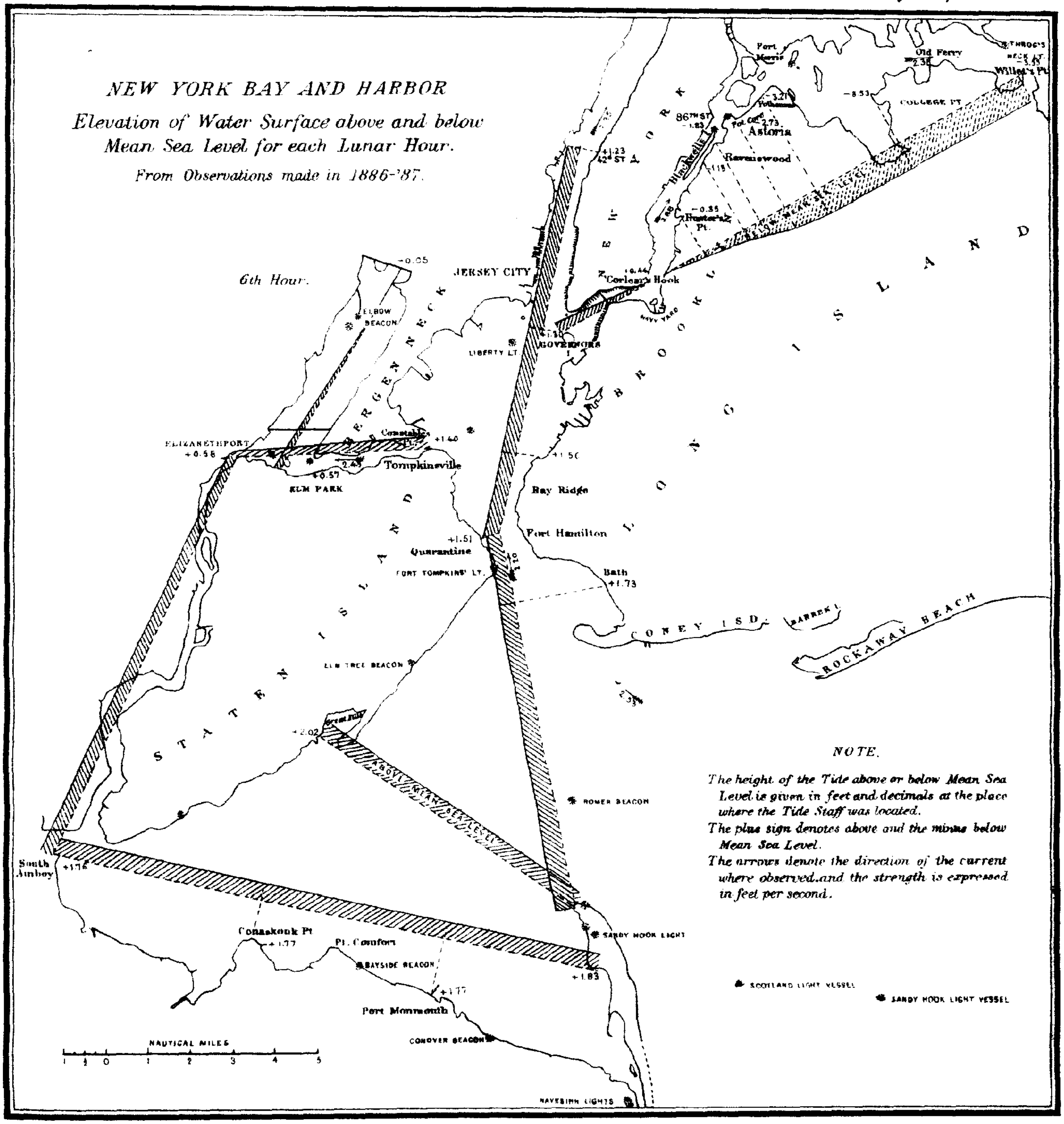

NEW YORK BAY AND HARBOR
Elevation of Water Surface above and below Mean Sea Level for each Lunar Hour.
From Observations made in 1886-'87.
1st Hour.
NOTE
The height of the Tide above or below Mean Sea Level is given in feet and decimals at the place where the Tide Staff was located.
The plus sign denotes above and the minus below Mean Sea Level.
The arrows denote the direction of the current where observed, and the strength is expressed in feet per second.
NEW YORK
LONG ISLAND
STATEN ISLAND
BERGEN NECK
CONEY ISD.
ROCKAWAY BEACH
JERSEY CITY
ASTORIA
Ravenswood
ELIZABETHPORT
ELM PARK
Tompkinsville
Bay Ridge
Fort Hamilton
Quarantine
FORT TOMPKINS LT.
Bath
ELM TREE BEACON
ROMER BEACON
SANDY HOOK LIGHT
South Amboy
Conaskonk Pt
Pt. Comfort
BAYSIDE BEACON
Port Monmouth
CONOVER BEACON
NAVESINK LIGHTS
SCOTLAND LIGHT VESSEL
SANDY HOOK LIGHT VESSEL
NAUTICAL MILES
-0.78
-1.80
-1.37
-1.90
-1.92
-1.99
-1.96
-1.87
-0.74
-0.28
+0.70
+2.07
+2.63
+2.60

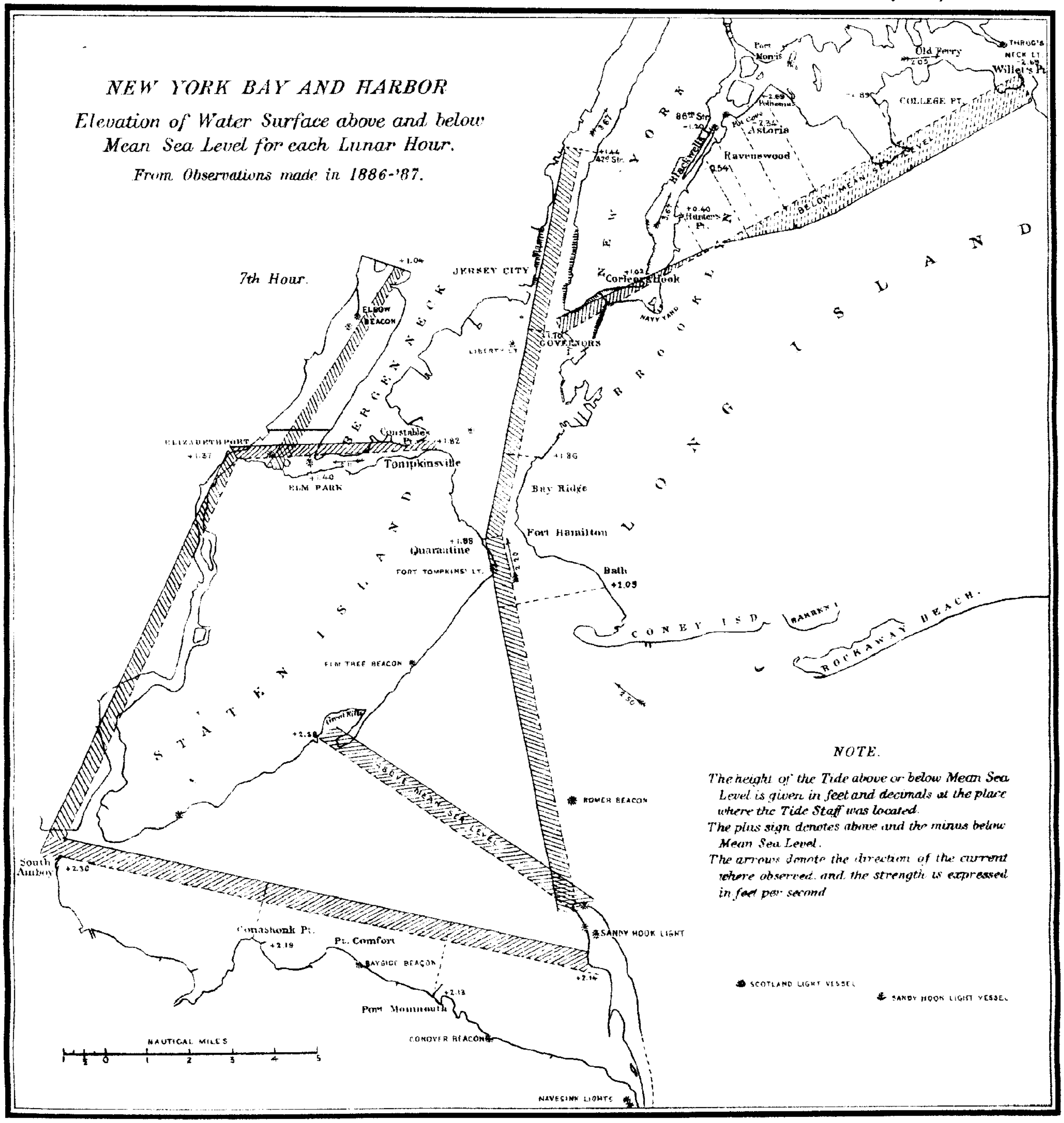

NEW YORK BAY AND HARBOR
Elevation of Water Surface above and below Mean Sea Level for each Lunar Hour.
From Observations made in 1886-'87.
2nd Hour.
JERSEY CITY
NEW YORK
BERGEN NECK
LIBERTY LT.
ELIZABETHPORT
−1.86
ELM PARK
Tompkinsville
−2.03
−2.07
Bay Ridge
Fort Hamilton
−1.99
Quarantine
FORT TOMPKINS' LT.
Bath
−1.97
CONEY ISD.
ROCKAWAY BEACH
LONG ISLAND
BROOKLYN
STATEN ISLAND
ELM TREE BEACON
ASTORIA
Ravenswood
0.93
−1.17
−1.97
−1.43
−2.19
South Amboy
Conaskonk Pt.
−2.06
Pt. Comfort
BAYSIDE BEACON
Port Monmouth
−1.97
−1.94
CONOVER BEACON
ROMER BEACON
SANDY HOOK LIGHT
SCOTLAND LIGHT VESSEL
SANDY HOOK LIGHT VESSEL
NAVESINK LIGHTS
Old Ferry Pt.
THROG'S NECK LT.
+0.65
+0.66
NAUTICAL MILES
NOTE
The height of the Tide above or below Mean Sea Level is given in feet and decimals at the place where the Tide Staff was located.
The plus sign denotes above and the minus below Mean Sea Level.
The arrows denote the direction of the current where observed, and the strength is expressed in feet per second.

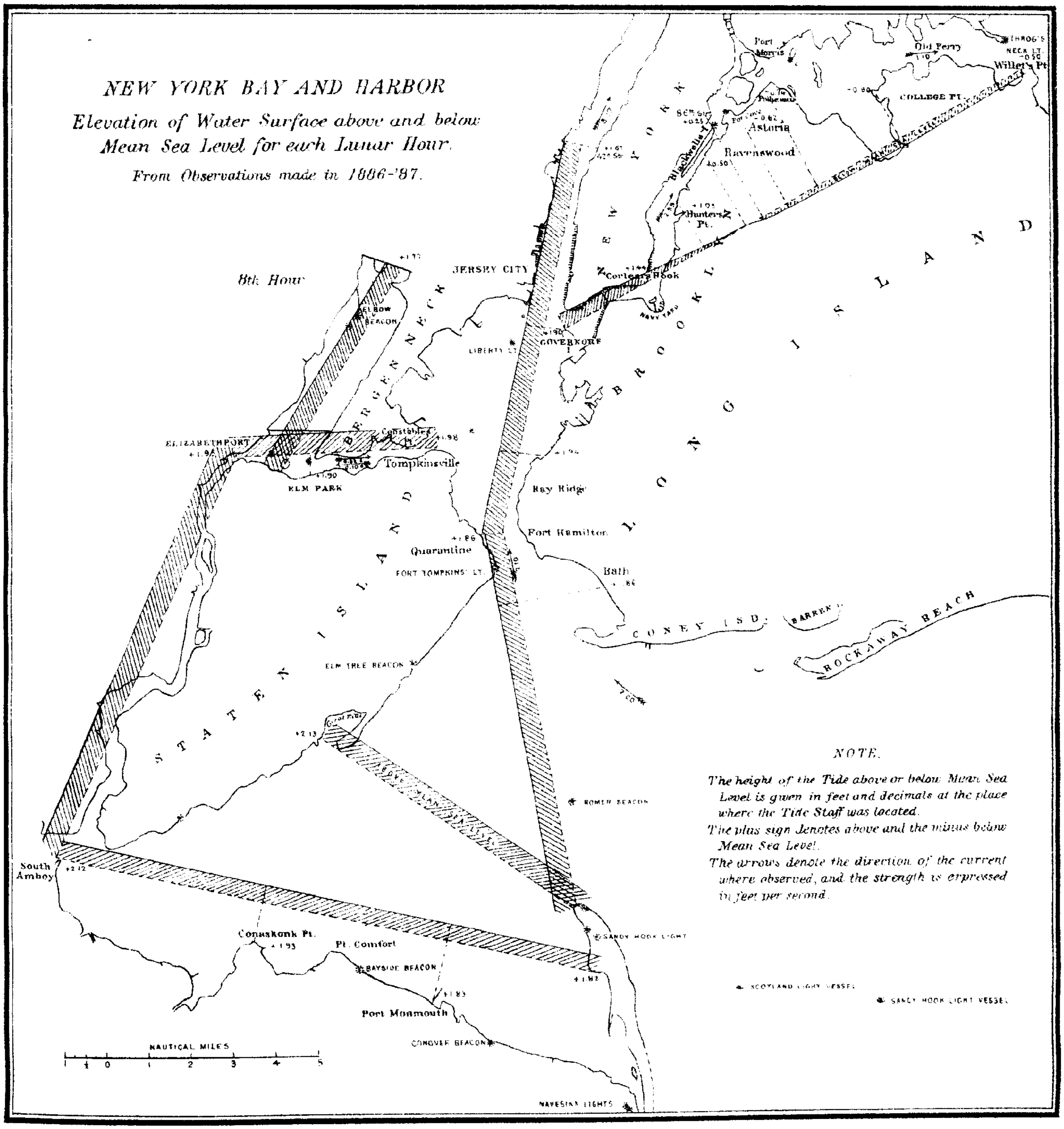

NEW YORK BAY AND HARBOR
Elevation of Water Surface above and below Mean Sea Level for each Lunar Hour.
From Observations made in 1886-'87.
3rd Hour.
NOTE.
The height of the Tide above or below Mean Sea Level is given in feet and decimals at the place where the Tide Staff was located.
The plus sign denotes above and the minus below Mean Sea Level.
The arrows denote the direction of the current where observed, and the strength is expressed in feet per second.
NAUTICAL MILES
JERSEY CITY
LIBERTY LT.
ELIZABETHPORT
-2.02
ELM PARK
-1.85
Tompkinsville
Constable Pt.
-1.48
-1.50
Bay Ridge
Fort Hamilton
Quarantine
-1.47
Bath
-1.43
ELM TREE BEACON
ROMER BEACON
SANDY HOOK LIGHT
South Amboy
-1.77
Conaskonk Pt.
-1.53
Pt. Comfort
BAYSIDE BEACON
-1.56
Port Monmouth
-1.37
CONOVER BEACON
NAVESINK LIGHTS
SCOTLAND LIGHT VESSEL
SANDY HOOK LIGHT VESSEL
ASTORIA
-1.85
Ravenswood
-2.20
-2.04
86TH ST
-1.64
-1.95
-1.79
-1.92
COLLEGE PT.
Old Ferry Pt.
THROGS NECK LT.
-1.85
-1.96
ELBOW BEACON
-2.31
NEW YORK
BERGEN NECK
STATEN ISLAND
BROOKLYN
LONG ISLAND
CONEY ISD.
ROCKAWAY BEACH
BELOW MEAN SEA LEVEL

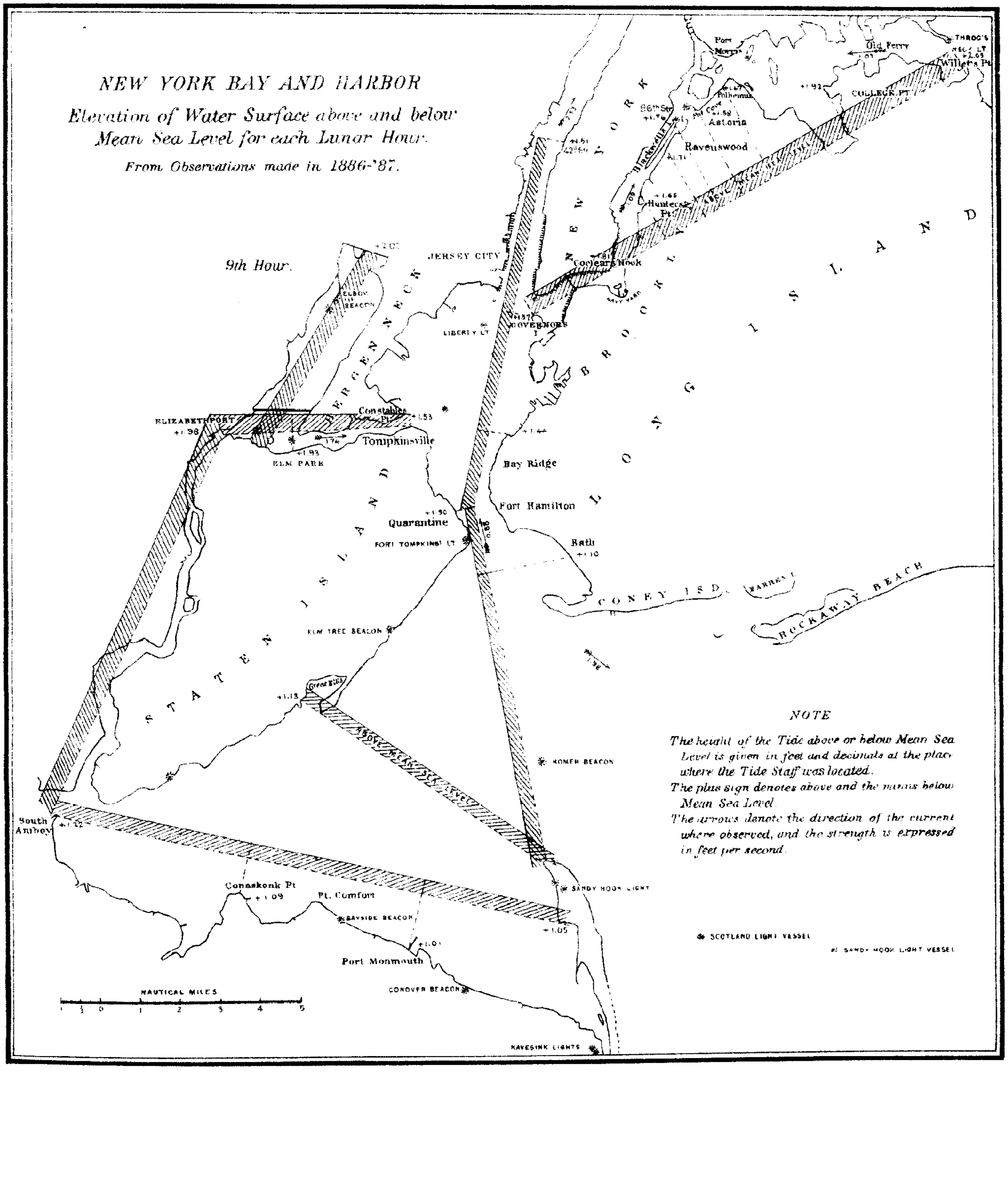

NEW YORK BAY AND HARBOR
Elevation of Water Surface above and below Mean Sea Level for each Lunar Hour.
From Observations made in 1886-'87.
4th Hour.
NOTE
The height of the Tide above or below Mean Sea Level is given in feet and decimals at the place where the Tide Staff was located.
The plus sign denotes above and the minus below Mean Sea Level.
The arrows denote the direction of the current where observed, and the strength is expressed in feet per second.
JERSEY CITY
ELIZABETHPORT
ELM PARK
Tompkinsville
Bay Ridge
Fort Hamilton
Quarantine
Bath
CONEY ISD.
BARREN I.
ROCKAWAY BEACH
STATEN ISLAND
LONG ISLAND
BROOKLYN
NEW YORK
BERGEN NECK
ASTORIA
Ravenswood
LIBERTY LT.
Governors I.
NAVY YARD
ELM TREE BEACON
ROMER BEACON
SANDY HOOK LIGHT
South Amboy
Conaskonk Pt.
Pt. Comfort
BAYSIDE BEACON
Port Monmouth
CONOVER BEACON
NAVESINK LIGHTS
SCOTLAND LIGHT VESSEL
SANDY HOOK LIGHT VESSEL
NAUTICAL MILES
THROG'S NECK LT.
Old Ferry Pt.
COLLEGE PT.
-2.21
-1.67
-1.57
-0.40
-0.33
-0.19
-0.10
-0.15
-0.22
-0.27
-0.10
-1.29
-1.92
-2.28
-2.59
-2.97
-3.13

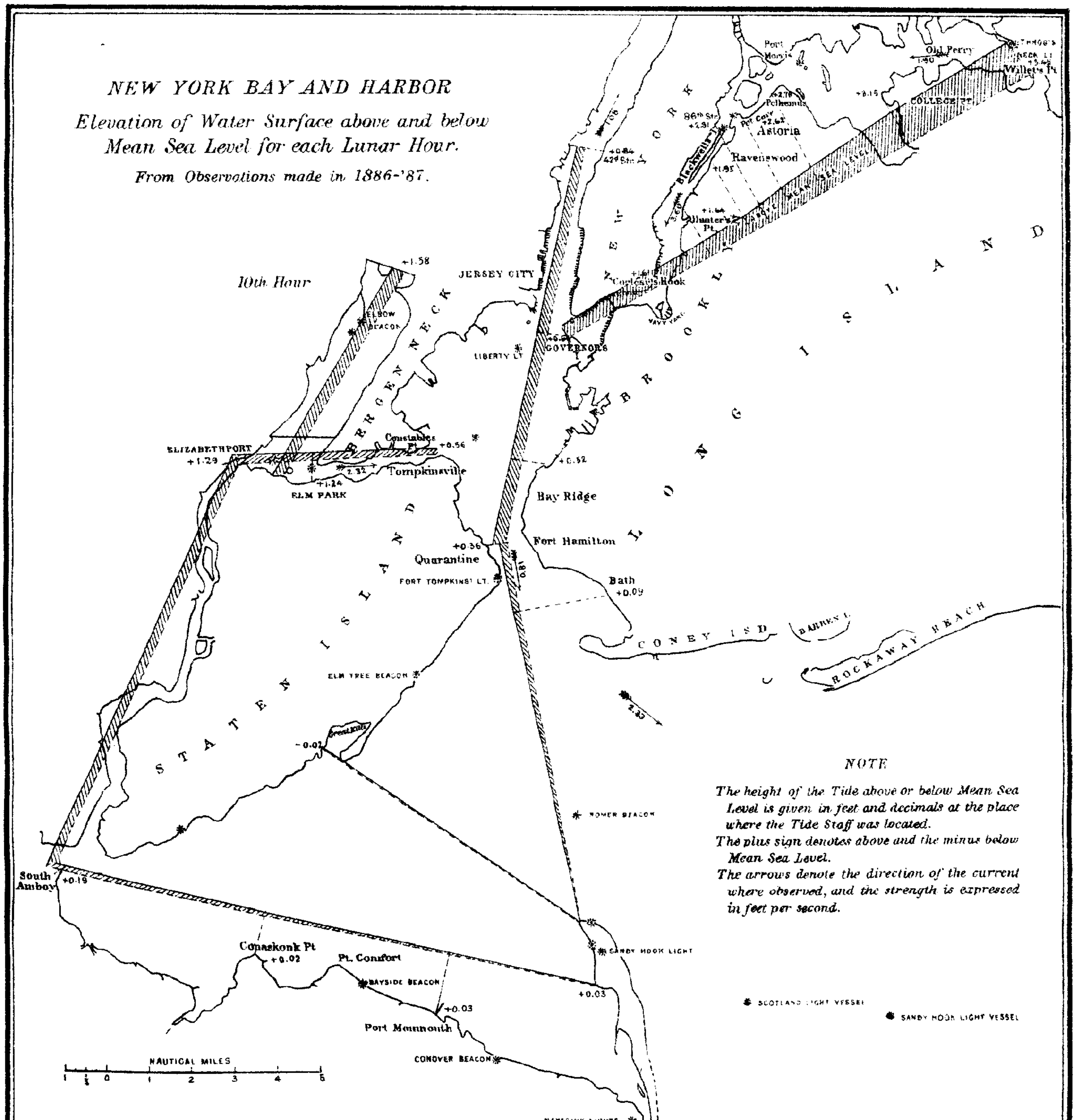

NEW YORK BAY AND HARBOR
Elevation of Water Surface above and below Mean Sea Level for each Lunar Hour.
From Observations made in 1886-'87.
5th Hour
NOTE
The height of the Tide above or below Mean Sea Level is given in feet and decimals at the place where the Tide Staff was located.
The plus sign denotes above and the minus below Mean Sea Level.
The arrows denote the direction of the current where observed, and the strength is expressed in feet per second.
NEW YORK
LONG ISLAND
STATEN ISLAND
BERGEN NECK
JERSEY CITY
ELIZABETHPORT
-0.55
ELM PARK
+0.54
Tompkinsville
+0.61
LIBERTY LT.
ASTORIA
COLLEGE PT
Old Ferry Pt.
THROG'S NECK LT.
-3.45
-3.27
-2.12
86TH ST
Ravenswood
-1.08
-0.50
Corlear's Hook
BELOW MEAN SEA LEVEL
+0.75
Bay Ridge
Fort Hamilton
+0.80
Quarantine
FORT TOMPKINS' LT.
Bath
+0.92
CONEY ISD.
BARREN I.
ROCKAWAY BEACH
ELM TREE BEACON
ABOVE MEAN SEA LEVEL
ROMER BEACON
+0.95
South Amboy
Conaskonk Pt.
+1.11
Pt. Comfort
BAYSIDE BEACON
+0.94
Port Monmouth
+0.92
SANDY HOOK LIGHT
SCOTLAND LIGHT VESSEL
SANDY HOOK LIGHT VESSEL
CONOVER BEACON
NAVESINK LIGHTS
NAUTICAL MILES
1 0 1 2 3 4 5
-1.25
+0.58
+0.93
2.54

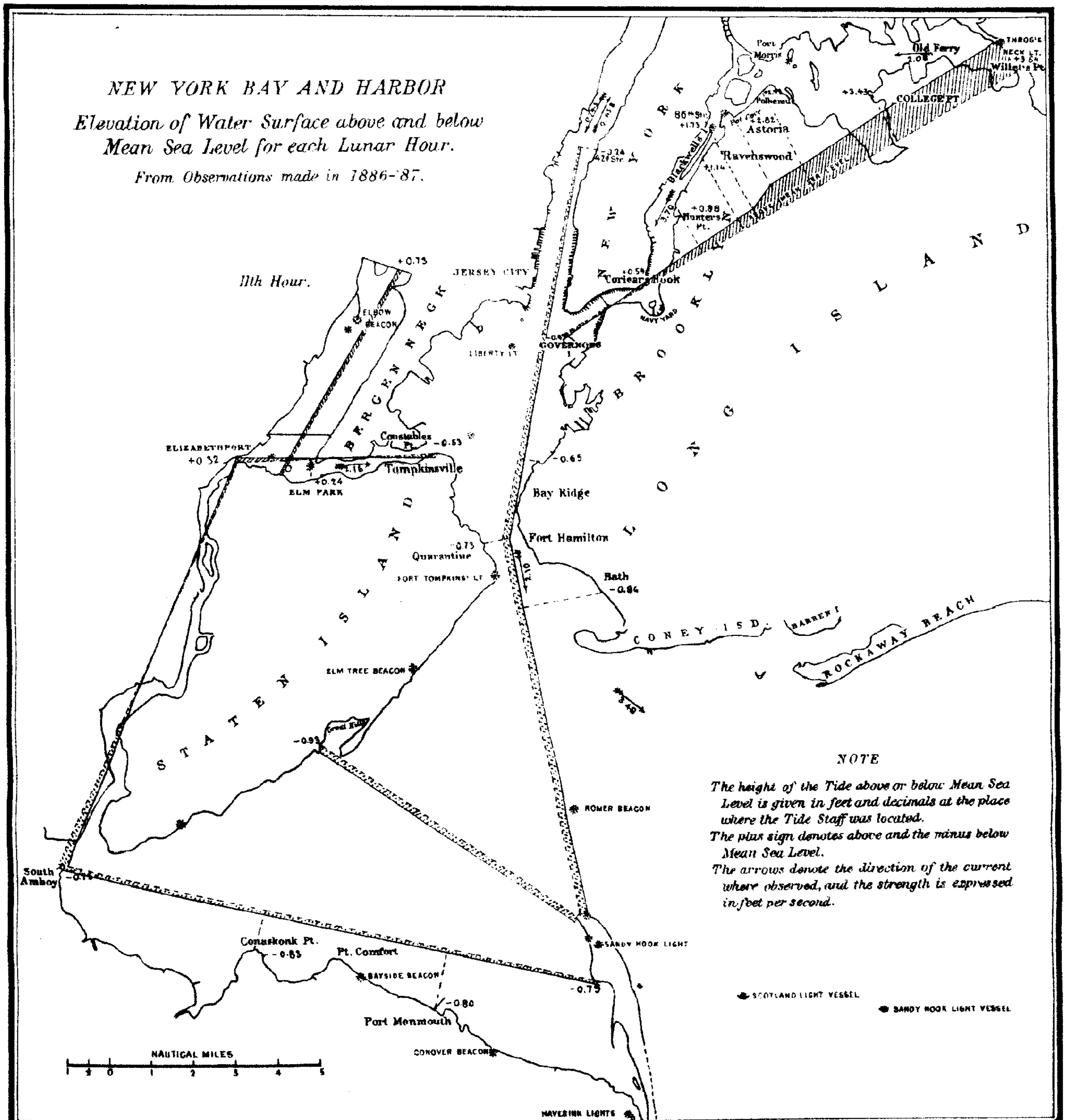

NEW YORK BAY AND HARBOR
Elevation of Water Surface above and below Mean Sea Level for each Lunar Hour.
From Observations made in 1886-'87.
6th Hour.
NOTE.
The height of the Tide above or below Mean Sea Level is given in feet and decimals at the place where the Tide Staff was located.
The plus sign denotes above and the minus below Mean Sea Level.
The arrows denote the direction of the current where observed, and the strength is expressed in feet per second.
JERSEY CITY
BERGEN NECK
ELIZABETHPORT
+0.58
ELBOW BEACON
Tompkinsville
ELM PARK
Quarantine
FORT TOMPKINS' LT.
ELM TREE BEACON
STATEN ISLAND
+2.02
South Amboy
Conaskonk Pt
+1.77
Pt. Comfort
BAYSIDE BEACON
Port Monmouth
CONOVER BEACON
NAVESINK LIGHTS
SANDY HOOK LIGHT
+1.83
ROMER BEACON
SCOTLAND LIGHT VESSEL
SANDY HOOK LIGHT VESSEL
CONEY ISD.
ROCKAWAY BEACH
Bath
+1.73
Fort Hamilton
Bay Ridge
LONG ISLAND
BROOKLYN
NEW YORK
LIBERTY LT.
GOVERNORS I.
Corlears Hook
NAVY YARD
Astoria
Ravenswood
Hunter's Pt.
86TH ST.
42D ST.
+1.23
Port Morris
Old Ferry
Willet's Pt.
COLLEGE PT.
NAUTICAL MILES
1 ½ 0 1 2 3 4 5


NEW YORK BAY AND HARBOR
Elevation of Water Surface above and below Mean Sea Level for each Lunar Hour.
From Observations made in 1886-'87.
7th Hour.
NOTE.
The height of the Tide above or below Mean Sea Level is given in feet and decimals at the place where the Tide Staff was located.
The plus sign denotes above and the minus below Mean Sea Level.
The arrows denote the direction of the current where observed, and the strength is expressed in feet per second.
JERSEY CITY
ELIZABETHPORT
ELM PARK
Tompkinsville
Quarantine
FORT TOMPKINS' LT.
ELM TREE BEACON
Bay Ridge
Fort Hamilton
Bath
+2.05
CONEY ISD.
ROCKAWAY BEACH
BERGEN NECK
STATEN ISLAND
LONG ISLAND
NEW YORK
BROOKLYN
Corlears Hook
Hunters Pt.
Ravenswood
Astoria
Port Morris
Old Ferry
Willets Pt.
COLLEGE PT.
GOVERNORS I.
South Amboy
+2.30
Conaskonk Pt.
+2.19
Pt. Comfort
BAYSIDE BEACON
+2.13
Port Monmouth
CONOVER BEACON
SANDY HOOK LIGHT
+2.16
ROMER BEACON
SCOTLAND LIGHT VESSEL
SANDY HOOK LIGHT VESSEL
NAVESINK LIGHTS
NAUTICAL MILES
0 1 2 3 4 5


NEW YORK BAY AND HARBOR
Elevation of Water Surface above and below Mean Sea Level for each Lunar Hour.
From Observations made in 1886-'87.
8th Hour
NOTE.
The height of the Tide above or below Mean Sea Level is given in feet and decimals at the place where the Tide Staff was located.
The plus sign denotes above and the minus below Mean Sea Level.
The arrows denote the direction of the current where observed, and the strength is expressed in feet per second.
NEW YORK
LONG ISLAND
BROOKLYN
STATEN ISLAND
BERGEN NECK
JERSEY CITY
Port Morris
Old Ferry
THROG'S NECK LT.
Willet's Pt.
COLLEGE PT.
Astoria
Ravenswood
Hunters Pt.
Corlears Hook
NAVY YARD
GOVERNORS I.
LIBERTY I.
ELBOW BEACON
ELIZABETHPORT
Constables Pt.
Tompkinsville
ELM PARK
Bay Ridge
Fort Hamilton
Quarantine
FORT TOMPKINS LT.
Bath
CONEY ISD.
BARREN I.
ROCKAWAY BEACH
ELM TREE BEACON
ROMER BEACON
South Amboy
Conaskonk Pt.
Pt. Comfort
BAYSIDE BEACON
Port Monmouth
CONOVER BEACON
SANDY HOOK LIGHT
SCOTLAND LIGHT VESSEL
SANDY HOOK LIGHT VESSEL
NAVESINK LIGHTS
NAUTICAL MILES
1 0 1 2 3 4 5


NEW YORK BAY AND HARBOR
Elevation of Water Surface above and below Mean Sea Level for each Lunar Hour.
From Observations made in 1886-'87.
9th Hour.
NOTE
The height of the Tide above or below Mean Sea Level is given in feet and decimals at the place where the Tide Staff was located.
The plus sign denotes above and the minus below Mean Sea Level.
The arrows denote the direction of the current where observed, and the strength is expressed in feet per second.
NAUTICAL MILES
JERSEY CITY
ELIZABETHPORT
+1.98
Constables Pt.
+1.55
Tompkinsville
+1.93
ELM PARK
Quarantine
+1.90
FORT TOMPKINS LT
Fort Hamilton
Bay Ridge
Bath
+1.10
CONEY ISD.
ROCKAWAY BEACH
ELM TREE BEACON
STATEN ISLAND
LONG ISLAND
BROOKLYN
NEW YORK
BERGEN NECK
LIBERTY LT
GOVERNORS I.
Corlears Hook
Astoria
Ravenswood
Hunters Pt
+1.65
86th St
COLLEGE PT
Willets Pt
THROG'S NECK LT
+2.05
Old Ferry
Fort Morris
+1.13
ABOVE MEAN SEA LEVEL
South Amboy
+1.12
ROMER BEACON
SANDY HOOK LIGHT
+1.05
Conaskonk Pt
+1.09
Pt. Comfort
BAYSIDE BEACON
+1.01
Port Monmouth
CONOVER BEACON
NAVESINK LIGHTS
SCOTLAND LIGHT VESSEL
SANDY HOOK LIGHT VESSEL


NEW YORK BAY AND HARBOR
Elevation of Water Surface above and below Mean Sea Level for each Lunar Hour.
From Observations made in 1886-'87.
10th Hour
NOTE
The height of the Tide above or below Mean Sea Level is given in feet and decimals at the place where the Tide Staff was located.
The plus sign denotes above and the minus below Mean Sea Level.
The arrows denote the direction of the current where observed, and the strength is expressed in feet per second.
NAUTICAL MILES
JERSEY CITY
BERGEN NECK
ELIZABETHPORT
+1.29
ELM PARK
+1.24
Tompkinsville
+0.56
+1.58
LIBERTY LT
GOVERNORS
Bay Ridge
Fort Hamilton
Quarantine
+0.36
FORT TOMPKINS' LT.
Bath
+0.09
CONEY ISD
ROCKAWAY BEACH
STATEN ISLAND
LONG ISLAND
BROOKLYN
NEW YORK
Astoria
Ravenswood
Hunter's Pt.
Port Morris
Old Ferry
Willet's Pt.
COLLEGE PT.
ELM TREE BEACON
ROMER BEACON
SANDY HOOK LIGHT
SCOTLAND LIGHT VESSEL
SANDY HOOK LIGHT VESSEL
South Amboy
+0.19
Conaskonk Pt
+0.02
Pt. Comfort
BAYSIDE BEACON
+0.03
Port Monmouth
CONOVER BEACON
NAVESINK LIGHTS
-0.02
+0.03


NEW YORK BAY AND HARBOR
Elevation of Water Surface above and below Mean Sea Level for each Lunar Hour.
From Observations made in 1886-'87.
11th Hour.
NOTE
The height of the Tide above or below Mean Sea Level is given in feet and decimals at the place where the Tide Staff was located.
The plus sign denotes above and the minus below Mean Sea Level.
The arrows denote the direction of the current where observed, and the strength is expressed in feet per second.
JERSEY CITY
BERGEN NECK
ELBOW BEACON
ELIZABETHPORT
+0.32
ELM PARK
+0.24
Constables Pt.
-0.53
Tompkinsville
LIBERTY LT
GOVERNORS I
NAVY YARD
Corlears Hook
Hunters Pt.
+0.88
Ravenswood
Astoria
Blackwells I
Port Morris
Old Ferry
THROG'S NECK LT.
Willets Pt.
COLLEGE PT
NEW YORK
BROOKLYN
LONG ISLAND
STATEN ISLAND
Bay Ridge
-0.65
Fort Hamilton
-0.73
Quarantine
FORT TOMPKINS LT
Bath
-0.84
CONEY ISD
BARREN I
ROCKAWAY BEACH
ELM TREE BEACON
Great Kills
-0.93
ROMER BEACON
South Amboy
SANDY HOOK LIGHT
-0.75
Conaskonk Pt.
-0.83
Pt. Comfort
BAYSIDE BEACON
-0.80
Port Monmouth
CONOVER BEACON
NAVESINK LIGHTS
SCOTLAND LIGHT VESSEL
SANDY HOOK LIGHT VESSEL
NAUTICAL MILES
1 0 1 2 3 4 5

APPENDIX No. 10.—1888.

HEIGHTS FROM SPIRIT-LEVELING OF PRECISION BETWEEN MOBILE, ALA., AND OKOLONA, MISS.

Observations by J. B. WEIR, Assistant, and J. E. McGRATH, Subassistant, in 1884, 1886, and 1887. Report by CHARLES A. SCHOTT, Assistant.

COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE,
September 28, 1888.

DEAR SIR: I herewith respectfully submit a report on the results of spirit-leveling of precision between Mobile, Ala., and Okolona, Miss., 1884-'86-'87.

Route line of levels.—The line follows the Mobile and Ohio Railroad throughout, and was subdivided in four parts, viz: Mobile to Citronelle, Ala., leveled in 1884; Citronelle to Quitman, Miss., in 1887, Quitman to Meridian, Miss., in 1886, and Meridian to Okolona in 1884. The respective lengths of the parts are as follows: 53.7, 123.0, 42.6 and 204.2 kilomètres or 33.3, 76.4, 26.5 and 126.9 statute miles; total development, 423.5 kilometres, or 263.1 statute miles. The bench-mark at Mobile was connected with the average tidal level of the Gulf of Mexico, at Biloxi, Miss., as reported by me August 4, 1887.*

Observers and dates of levelings.—The line from Mobile to Citronelle was leveled by Assistant J. B. Weir between February 18 and March 6, 1884; the part from Citronelle to Quitman was leveled by J. B. Weir and Sub-assistant J, E. McGrath between January 19 and March 23, 1887; the part from Quitman to Meridian by J. B. Weir between April 19 and May 12, 1886, and the last part, from Meridian to Okolona, by the same observer between March 8 and May 5, 1884.

Instruments.—Three instruments were employed; for the first and last parts spirit-level No. 1 (described in Appendix 11, Report for 1880); for the second part spirit-levels Nos. 2 and 3 (described in Appendix 15, Report for 1879), and for the third part No. 3 alone.

The inequality of collars was as follows: Object end larger (+); all observations by J. B. Weir.

	″	
Level No. 1	—3.36	From observations of February 7 and 8, 1884.
	—2.87	From observations of May 14 and 15, 1884.
Level No. 2	—1.12	From observations of January 12, 1887.
	+0.72	From observations of April 1 and 2, 1887.
Level No. 3	—0.78	From observations of May 24, 1886.
	—1.523	From observations of January 3 and 4, 1887.
	—0.026	From observations of March 31 and April 1, 1887.

* See Appendix No. 9, Report for 1887.

Value of one turn of micrometer screw.

	"		
Level No. 1	443.1	August and September, 1887.	
Level No. 2	259.6	April 8, 1887.	
Level No. 3	255.6	March 6, 1879.	Adopted, 257".5
	257.4	June 16, 1880.	
	257.6	April 8, 1887.	

Value of one division of level. *Value of angular distance of telemeter threads.*

	"		′ ″	
No. 1	5.60	July 23, 1883.	34 05.4	October 29, 1883.
No. 2	3.04	January 10, 1887.	16 39.3	January 19, 1887.
	3.37	April 2, 1887.		
No. 3	3.88	May 24, 1886.	18 40.6	February 20, 1886.
	3.37	January 6, 1887.	14 00.7	January 19, 1887, new diaphragm.
	3.09	April 2 and 4, 1887.		

Rods E and F were used throughout; the metric graduation is correct at the temperatures 62°.1 F. (16°.7 C.) and 66°.1 F. (18°.9 C.), respectively (Report of March 9, 1888);* projection of rod beyond the zero division:

Date.	Rod E.	Rod F.	Date.	Rod E.	Rod F.
	mm.	*mm.*		*mm.*	*mm.*
October 30, 1883.	64.0	61.0	February 3, 1886.	63.1	60.4
May 6, 1884.	63.3	60.7	April 4, 1887.	62.7	60.1

Coefficient of expansion of brass, 0.000010 for 1° Fahr., or 0.000018 for 1° C.

Method of observing.—The method pursued in 1884 was that of running two *simultaneous* and parallel lines, as described in Appendix 11, Report for 1880; alternate sections of the line were run in the sense of forward and backward direction; average distance from staff to staff about 225 m.; when setting the telescope for "horizon" the bubble was either made to play in the middle or one end of it was set to a fixed graduation line. In 1884, experience on another line having shown the insufficiency of the method heretofore followed, it was subsequently changed to that of running two independent lines, one forward, the other backward. In 1887, spirit-level No. 2 was used for the backward line by McGrath, and No. 3 for the forward line by Weir. The distances between the staves in 1886 and in 1887 averaged about 190 m. The instrumental manipulation was the same as described in the leveling by the same party about New York Bay and Harbor in 1887 (Appendix No. 14, Report for 1887).

Computations and results.—The field computation was furnished by the observer; the second or office (and check) computation was made by L. A. Bauer, of the Computing Division, who was aided in the 1884 computations by Subassistant C. H. Van Orden, then temporarily assigned to the Computing Division. These reductions were made in accordance with the printed forms prepared for them, and include all needful corrections together with the computation of the probable errors of the results. In computing the latter, the probable errors depending on the comparison of parallel *simultaneous* lines were increased by one-fourth of their value in order to render them, as near as may be, comparable with the values derived from *independent* lines. The tabular form of the results is the same as that adopted for similar work in preceding reports; the distances between the bench-marks are given in kilometres, and their heights above the average Gulf level are stated in metres. The partial and the total accumulated discrepancies are given in millimetres.

* See Appendix No. 14, Report for 1887, p. 276.

Results from geodetic spirit-leveling in Alabama and Mississippi, 1884–'87, from Mobile, Ala., to Okolona, Miss.

SECTION I.—FROM MOBILE TO CITRONELLE, ALA.

[February to March, 1884; Assistant J. B. Weir, observer; instrument, geodetic micrometer level No. 1; method, two simultaneous parallel lines in one direction.]

Date, 1884.	Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Line with Rod E.	Line with Rod F.	Mean.	Discrepancy. Partial. E.–F.	Discrepancy. Total accumulated.	Height of mark above average Gulf level (at Biloxi, Miss).
			Km.	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
Feb.	A		----	0.000	------	------	------	----	0.0	+ 3.7351†
21	A	Astron. station.	0.217	----	+ 0.9209	+ 0.9214	+ 0.9212	−0.5	----	+ 4.6563
18	A‡	1	1.248	1.248	− 1.8318	− 1.8322	−1.8320	+0.4	+ 0.4	+ 1.9031
19	1	2	0.426	1.674	− 0.9829	− 0.9820	−0.9824	−0.9	− 0.5	+ 0.9207
20	2	3	1.152	2.826	+ 0.1557	+ 0.1568	+0.1562	−1.1	− 1.6	+ 1.0769
20	3	4	0.903	3.729	+ 0.9327	+ 0.9357	+0.9342	−3.0	− 4.6	+ 2.0111
20	4	5	1.280	5.009	+ 5.2445	+ 5.2438	+5.2442	+0.7	− 3.9	+ 7.2553
20	5	6	1.359	6.368	+ 1.9577	+ 1.9563	+1.9570	+1.4	− 2.5	+ 9.2123
21	6	7	1.116	7.484	+ 1.1011	+ 1.1019	+1.1015	−0.8	− 3.3	+10.3138
21	7	8	1.098	8.582	+ 0.8665	+ 0.8682	+0.8674	−1.7	− 5.0	+11.1812
21	8	I	1.315	9.897	+ 0.4223	+ 0.4182	+0.4202	+4.1	− 0.9	+11.6014
Mar.										
3	I	28	1.398	11.295	− 1.6982	− 1.6998	−1.6990	+1.6	+ 0.7	+ 9.9024
3	28	29	1.190	12.485	+ 1.6832	+ 1.6848	+1.6840	−1.6	− 0.9	+11.5864
3	29	30	1.196	13.681	− 4.8106	− 4.8090	−4.8098	−1.6	− 2.5	+ 6.7766
3	30	31	1.438	15.119	− 1.4361	− 1.4376	−1.4368	+1.5	− 1.0	+ 5.3398
4	31	32	1.632	16.751	+ 0.5033	+ 0.5013	+0.5023	+2.0	+ 1.0	+ 5.8421
4	32	33	1.022	17.773	+ 2.7116	+ 2.7083	+2.7100	+3.3	+ 4.3	+ 8.5521
4	33	34	1.491	19.264	+ 1.5386	+ 1.5398	+1.5392	−1.2	+ 3.1	+10.0913
4	34	35	1.320	20.584	+ 1.0625	+ 1.0621	+1.0623	+0.4	+ 3.5	+11.1536
5	35	36	1.376	21.960	+ 0.8965	+ 0.8953	+0.8959	+1.2	+ 4.7	+12.0495
5	36	37	1.556	23.516	+ 1.8262	+ 1.8279	+1.8270	−1.7	+ 3.0	+13.8765
5 and 6	37	III§	1.024	24.540	+ 1.2194*	+ 1.2194*	+1.2194	0.0	+ 3.0	+15.0959
Feb.										
29	III‖	27	1.447	25.987	+ 1.0163	+ 1.0153	+1.0158	+1.0	+ 4.0	+16.1117
29	27	26	1.385	27.372	+ 1.1242	+ 1.1286	+1.1264	−4.4	− 0.4	+17.2381
29	26	25	1.360	28.732	+ 2.0834	+ 2.0833	+2.0834	+0.1	− 0.3	+19.3215
29	25	24	1.489	30.221	+ 1.2116	+ 1.2173	+1.2144	−5.7	− 6.0	+20.5359
28	24	23	1.530	31.751	+ 2.5078	+ 2.5083	+2.5080	−0.5	− 6.5	+23.0439
28	23	22	1.422	33.173	+ 2.8590	+ 2.8605	+2.8598	−1.5	− 8.0	+25.9037
28	22	21	1.476	34.649	+ 1.0039	+ 1.0017	+1.0028	+2.2	− 5.8	+26.9065
28	21	20	1.444	36.093	+ 2.9282	+ 2.9246	+2.9264	+3.6	− 2.2	+29.8329
27	20	19	1.456	37.549	+ 2.7314	+ 2.7336	+2.7325	−2.2	− 4.4	+32.5654

* Wherever the asterisk (*) is appended, the result given is the mean of two determinations.
† Taken from Table III, report of August 4, 1887, on the line from Mobile to Carrollton, 1885-'86, Appendix No. 9. Report for 1887, p. 202.
‡ From A to 37 was measured in the forward direction, *i. e., from* Mobile; also II to B.
§ Measured forwards and backwards.
‖ From III to II was measured in the backward direction, *i. e., towards* Mobile.

***Results from geodetic spirit-leveling in Alabama and Mississippi*, 1884-'87, *etc.*—Continued.**

SECTION I.—FROM MOBILE TO CITRONELLE, ALA.—Continued.

Date, 1884.	Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Line with Rod E.	Line with Rod F.	Mean.	Discrepancy. Partial. E.-F.	Discrepancy. Total accumulated.	Height of mark above average Gulf level (at Biloxi, Miss.).
			Km.	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
Feb.										
27	19	18	1.694	39.243	+ 3.7148	+ 3.7132	+ 3.7140	+1.6	− 2.8	+ 36.2794
27	18	17	1.457	40.700	+ 2.0834	+ 2.0794	+ 2.0814	+4.0	+ 1.2	+ 38.3608
27	17	16	1.350	42.050	+ 3.3543	+ 3.3552	+ 3.3548	−0.9	+ 0.3	+ 41.7156
25	16	15	1.616	43.666	+ 8.3932	+ 8.3885	+ 8.3908	+4.7	+ 5.0	+ 50.1064
25	15	14	1.296	44.962	+ 9.9039	+ 9.9011	+ 9.9025	+2.8	+ 7.8	+ 60.0089
25	14	13	1.354	46.316	+10.1469	+10.1465	+10.1467	+0.4	+ 8.2	+ 70.1556
25	13	12	1.389	47.705	+10.4748	+10.4730	+10.4739	+1.8	+10.0	+ 80.6295
23	12	11	1.644	49.349	+12.1491	+12.1517	+12.1504	−2.6	+ 7.4	+ 92.7799
Feb. 23 and Mar. 6.	11	10†	1.410	50.759	+ 6.3383*	+ 6.3357*	+ 6.3370	+2.6	+10.0	+ 99.1169
Feb.										
23	10	9	1.410	52.169	+ 2.1606	+ 2.1615	+ 2.1610	−0.9	+ 9.1	+101.2779
23	9	II	1.407	53.576	− 3.3083	− 3.3047	− 3.3065	−3.6	+ 5.5	+ 97.9714
Mar.										
6	II	B†	0.089	53.665	+ 2.8522	+ 2.8508	+ 2.8515	+1.4	+ 6.9	+100.8229

SECTION II.—FROM CITRONELLE, ALA., TO QUITMAN, MISS.

[January to March, 1887; J. B. Weir and J. E. McGrath, observers; instruments, geodetic micrometer levels Nos. 2 and 3; method, two independent (forward and backward) lines.]

Date, 1887.		Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Direction of line. Forwards.	Direction of line. Backwards.	Mean.	Discrepancy. Partial. F.-B.	Discrepancy. Total accumulated.	Height of mark above average Gulf level (at Biloxi, Miss.).
				Km.	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
Jan.			B	----	53.665	------	------	------	----	----‡	+100.8229
19	27	B	1	0.412	54.077	− 4.8155	− 4.8164	− 4.8160	+0.9	+ 0.9	+ 96.0069
20	27	1	2	0.822	54.899	− 1.0528	− 1.0520	− 1.0524	−0.8	+ 0.1	+ 94.9545
20	20	2	3	1.223	56.122	+ 0.8535	+ 0.8585	+ 0.8560	−5.0	− 4.9	+ 95.8105
26	28	3	4	1.163	57.285	− 7.0782*	− 7.0787*	− 7.0784	+0.5	− 4.4	+ 88.7321
20	26	4	5	1.548	58.833	− 9.0714	− 9.0726	− 9.0720	+1.2	− 3.2	+ 79.6601
21	26	5	6	1.182	60.015	− 5.6822	− 5.6794	− 5.6808	−2.8	− 6.0	+ 73.9793
21	26	6	7	1.169	61.184	− 4.4006	− 4.3965	− 4.3986	−4.1	−10.1	+ 69.5807
21	26	7	8	1.166	62.350	+ 0.5830	+ 0.5823	+ 0.5826	+0.7	− 9.4	+ 70.1633
25		8	E_2	0.055	62.405	+ 1.5918	+ 1.5913	+ 1.5916	+0.5	− 8.9	+ 71.7549
21	25	8	9	1.544	63.894	− 3.3818	− 3.3778	− 3.3798	−4.0	−13.4	+ 66.7835
22	25	9	10	1.211	65.105	− 7.4439	− 7.4442	− 7.4440	+0.3	−13.1	+ 59.3395

* Wherever the asterisk (*) is appended the result given is the mean of two determinations.

† Measured forwards and backwards.

‡ Break in count due to change of method of leveling.

Results from geodetic spirit-leveling in Alabama and Mississippi, 1884–'87, etc.—Continued.

SECTION II.—FROM CITRONELLE, ALA., TO QUITMAN, MISS.—Continued.

Date, 1887.		Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Direction of line. Forwards.	Backwards.	Mean.	Discrepancy. Partial. F.–B.	Total accumulated.	Height of mark above average Gulf level (at Biloxi, Miss.).
				Km.	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
Jan.											
22	25	10	11	1.232	66.337	— 4.9992	— 5.0025	— 5.0008	+3.3	— 9.8	+ 54.3387
22	24	11	12	1.160	67.497	— 5.6149	— 5.6163	— 5.6156	+1.4	— 8.4	+ 48.7231
22	24	12	13	1.230	68.727	— 2.5240	— 2.5191	— 2.5216	—4.9	—13.3	+ 46.2015
Jan.	Feb.										
29	3	13	14	1.064	69.791	— 0.5995	— 0.5966*	— 0.5980	—2.9	—16.2	+ 45.6035
29	3	14	15	1.162	70.953	— 0.9768	— 0.9764	— 0.9766	—0.4	—16.6	+ 44.6269
29	3	15	16	0.556	71.509	+ 1.5286	+ 1.5323	+ 1.5304	—3.7	—20.3	+ 46.1573
Feb. 3.		16	F_2	0.066	71.575	+ 0.7811	+ 0.7811	+ 0.7811	0.0	—20.3	+ 46.9384
Jan.	Feb.										
29	2	16	17	1.136	72.645	— 1.4480	— 1.4470	— 1.4475	—1.0	—21.3	+44.7098
29	2	17	18	1.212	73.857	+ 1.6818	+ 1.6827	+ 1.6822	—0.9	—22.2	+46.3920
29	2	18	19	0.792	74.649	— 0.5309	— 0.5289	— 0.5299	—2.0	—24.2	+45.8621
31	2	19	20	1.020	75.669	+ 1.2917	+ 1.2911	+ 1.2914	+0.6	—23.6	+47.1535
31	2	20	21	0.688	76.357	— 0.4278	— 0.4248	— 0.4263	—3.0	—26.6	+46.7272
31	2	21	22	0.872	77.229	+ 0.6845	+ 0.6865	+ 0.6855	—2.0	—28.6	+47.4127
31	1	22	23	1.128	78.357	+ 0.6037	+ 0.6029	+ 0.6033	+0.8	—27.8	+48.0160
31	1	23	24	0.786	79.143	+ 0.4205	+ 0.4219	+ 0.4212	—1.4	—29.2	+48.4372
Feb.											
4	9	24	25	1.205	80.348	+ 1.8291	+ 1.8306	+ 1.8298	—1.5	—30.7	+50.2670
4	9	25	26	1.132	81.480	— 0.3722	— 0.3728	— 0.3725	+0.6	—30.1	+49.8945
4	9	26	27	1.096	82.576	+ 0.9159	+ 0.9179	+ 0.9169	—2.0	—32.1	+50.8114
10		27	G_2	0.206	82.782	+ 2.8057	+ 2.8061	+ 2.8059	—0.4	—32.5	+53.6173
4	9	27	28	1.144	83.720	+ 0.8665	+ 0.8632	+ 0.8648	+3.3	—28.8	+51.6762
4	9	28	29	1.036	84.756	+ 0.5452	+ 0.5455	+ 0.5454	—0.3	—29.1	+52.2216
5	9	29	30	1.046	85.802	— 0.2190	— 0.2211	— 0.2200	+2.1	—27.0	+52.0016
5	9	30	31	1.116	86.918	+ 0.7393	+ 0.7381	+ 0.7387	+1.2	—25.8	+52.7403
5	8	31	32	0.970	87.888	+ 3.0215	+ 3.0189	+ 3.0202	+2.6	—23.2	+55.7605
5	8	32	33	0.994	88.882	— 1.4565	— 1.4542	— 1.4554	—2.3	—25.5	+54.3051
7	8	33	34	1.167	90.049	+ 0.6966	+ 0.6988	+ 0.6977	—2.2	—27.7	+55.0028
7	8	34	35	1.144	91.193	+ 1.6486	+ 1.6470	+ 1.6478	+1.6	—26.1	+56.6506
7	8	35	36	1.090	92.283	+ 0.8140	+ 0.8088	+ 0.8114	+5.2	—20.9	+57.4620
7	8	36	37	0.990	93.273	+ 1.2506	+ 1.2496	+ 1.2501	+1.0	—19.9	+58.7121
11	15	37	38	1.236	94.509	+ 2.7057	+ 2.7040	+ 2.7048	+1.7	—18.2	+61.4169
15		38	H_2	0.132	94.641	+ 4.2486	+ 4.2496	+ 4.2491	—1.0	—19.2	+65.6660
11	15	38	39	1.141	95.650	+ 1.5428	+ 1.5393	+ 1.5410	+3.5	—14.7	+62.9579
11	15	39	40	1.094	96.744	+ 1.5942	+ 1.5949	+ 1.5946	—0.7	—15.4	+64.5525
11	15	40	41	1.123	97.867	+ 1.8447	+ 1.8451	+ 1.8449	—0.4	—15.8	+66.3974

Results from geodetic spirit-leveling in Alabama and Mississippi, 1884–'87, *etc.*—Continued.

SECTION II.—FROM CITRONELLE, ALA., TO QUITMAN, MISS.—Continued.

Date, 1887.		Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Direction of line. Forwards.	Difference of height between bench-marks. Direction of line. Backwards.	Difference of height between bench-marks. Mean.	Discrepancy. Partial. F.–B.	Discrepancy. Total accumulated.	Height of mark above average Gulf level (at Biloxi, Miss.).
Feb.				*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
11	15	41	42	1. 186	99. 053	+ 3. 0110	+ 3. 0094	+3. 0102	+1. 6	—14. 2	+69. 4076
11	15	42	43	1. 250	100. 303	+ 4. 4467	+ 4. 4488	+4. 4478	—2. 1	—16. 3	+73. 8554
12	14	43	44	1. 237	101. 540	+ 3. 2740	+ 3. 2766	+3. 2753	—2. 6	—18. 9	+77. 1307
12	14	44	45	0. 604	102. 144	+ 1. 4492	+ 1. 4478	+1. 4485	+1. 4	—17. 5	+78. 5792
16		45	I	0. 172	102. 316	+ 2. 1820	+ 2. 1825	+2. 1822	—0. 5	—18. 0	+80. 7614
12	14	45	46	1. 268	103. 412	— 7. 2246	— 7. 2250	—7. 2248	+0. 4	—17. 1	+71. 3544
12	14	46	47	1. 261	104. 673	— 6. 7489	— 6. 7519	—6. 7504	+3. 0	—14. 1	+64. 6040
12	14	47	48	1. 260	105. 933	— 7. 6697	— 7. 6731	—7. 6714	+3. 4	—10. 7	+56. 9326
12	14	48	49	1. 235	107. 168	— 3. 8713	— 3. 8752	—3. 8732	+3. 9	— 6. 8	+53. 0594
12	14	49	50	1. 257	108. 425	— 5. 6990	— 5. 7030	—5. 7010	+4. 0	— 2. 8	+47. 3584
17	22	50	51	1. 268	109. 693	— 4. 1655	— 4. 1659	—4. 1657	+0. 4	— 2. 4	+43. 1927
17	22	51	52	1. 218	110. 911	— 2. 7216	— 2. 7182	—2. 7199	—3. 4	— 5. 8	+40. 4728
17	22	52	53	1. 176	112. 087	— 1. 6746	— 1. 6728	—1. 6737	—1. 8	— 7. 6	+38. 7991
17	21	53	54	1. 200	113. 287	+ 1. 8816	+ 1. 8824	+1. 8820	—0. 8	— 8. 4	+40. 6811
17	21	54	55	1. 649	114. 936	+ 3. 7077	+ 3. 7051	+3. 7064	+2. 6	— 5. 8	+44. 3875
24		55	J_2	0. 178	115. 114	+ 1. 7545	+ 1. 7545	+1. 7545	0. 0	— 5. 8	+46. 1420
17	21	55	56	1. 228	116. 164	— 0. 0658	— 0. 0658	—0. 0658	0. 0	— 5. 8	+44. 3217
18	24	56	57	1. 228	117. 392	+ 1. 4393	+ 1. 4429	+1. 4411	—3. 6	— 9. 4	+45. 7628
18	24	57	58	1. 230	118. 622	+ 0. 5740	+ 0. 5731	+0. 5736	+0. 9	— 8. 5	+46. 3364
18	24	58	59	1. 154	119. 776	+ 0. 3765	+ 0. 3767	+0. 3766	—0. 2	— 8. 7	+46. 7130
18	23	59	60	1. 140	120. 916	+ 1. 2222	+ 1. 2246	+1. 2234	—2. 4	—11. 1	+47. 9364
18	23	60	61	1. 195	122. 111	+ 0. 7326	+ 0. 7359	+0. 7342	—3. 3	—14. 4	+48. 6706
18	23	61	62	1. 224	123. 335	— 2. 9125	— 2. 9104	—2. 9114	—2. 1	—16. 5	+45. 7592
19 25	23 25	62	63	1. 246	124. 581	+ 5. 7047*	+ 5. 7019*	+5. 7033	+2. 8	—13. 7	+51. 4625
19	23	63	64	1. 274	125. 855	— 1. 6232	— 1. 6209	—1. 6220	—2. 3	—16. 0	+49. 8405
23		64	K_2	0. 069	125. 924	+ 1. 4055	+ 1. 4059	+1. 4057	—0. 4	—16. 4	+51. 2462
19	23	64	65	0. 839	126. 694	— 3. 4054	— 3. 4082	—3. 4068	+2. 8	—13. 2	+46. 4337
Feb.	Mar.										
25	2	65	66	1. 185	127. 879	— 2. 0457	— 2. 0471	—2. 0464	+1. 4	—11. 8	+44. 3873
25	2	66	67	0. 800	128. 679	+ 0. 5328	+ 0. 5333	+0. 5330	—0. 5	—12. 3	+44. 9203
26 Mar. 3	2 3	67	68	1. 253	129. 932	+ 6. 2356*	+ 6. 2390*	+6. 2373	—3. 4	—15. 7	+51. 1576
Feb.											
26	2	68	69	1. 203	131. 135	+ 0. 8183	+ 0. 8202	+0. 8192	—1. 9	—17. 6	+51. 9768
26	2	69	70	1. 208	132. 343	+ 1. 7455	+ 1. 7489	+1. 7472	—3. 4	—21. 0	+53. 7240
28	1	70	71	1. 672	134. 015	+ 4. 0734	+ 4. 0718	+4. 0726	+1. 6	—19. 4	+57. 7966
Mar. 3.		71	L_2	0. 068	134. 083	+ 1. 0279	+ 1. 0279	+1. 0279	0. 0	—19. 4	+58. 8245

* Wherever the asterisk (*) is appended, the result given is the mean of two determinations.

***Results from geodetic spirit-leveling in Alabama and Mississippi*, 1884–'87, *etc.*—Continued.**

SECTION II.—FROM CITRONELLE, ALA., TO QUITMAN, MISS.—Continued.

Date, 1887.		Bench-marks.		Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks.			Discrepancy.		Height of mark above average Gulf level (at Biloxi, Miss.).
		From	To			Direction of line.		Mean.	Partial. F.–B.	Total accumulated.	
						Forwards.	Backwards.				
				Km.	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm*	*Metres.*
Feb. 28 / Mar. 3	Mar. 1 & 3	71	72	1.214	135.229	− 2.9344	− 2.9378	−2.9361	+3.4	−16.0	+54.8605
Feb.											
28	1	72	73	1.179	136.408	+ 0.9055	+ 0.9063	+0.9059	−0.8	−16.8	+55.7664
28	1	73	74	1.180	137.588	− 5.2334	− 5.2348	−5.2341	+1.4	−15.4	+50.5323
28	1	74	75	1.230	138.818	+ 1.9919	+ 1.9934	+1.9926	−1.5	−16.9	+52.5249
Mar.											
4	11	75	76	1.228	140.046	+ 0.7223	+ 0.7173	+0.7198	+5.0	−11.9	+53.2447
4	11	76	77	1.126	141.172	+ 1.6953	+ 1.6916	+1.6934	+3.7	− 8.2	+54.9381
4 / 14	11 / 14	77	78	1.090	142.262	− 1.8516*	− 1.8478*	−1.8497	−3.8	−12.0	+53.0884
4	11	78	79	1.086	143.348	− 0.5293	− 0.5290	−0.5292	−0.3	−12.3	+52.5592
4	10	79	80	1.121	144.469	+ 0.5715*	+ 0.5746*	+0.5730	−3.1	−15.4	+53.1322
10		80	M_2	0.128	144.597	+ 1.0267	+ 1.0274	+1.0270	−0.7	−16.1	+54.1592
5	10	80	81	1.116	145.585	+ 0.6159	+ 0.6167	+0.6163	−0.8	−16.2	+53.7485
5	10	81	82	1.107	146.692	+ 0.2269	+ 0.2243	+0.2256	+2.6	−13.6	+53.9741
5	10	82	83	1.082	147.774	+ 0.4211	+ 0.4199	+0.4205	+1.2	−12.4	+54.3946
5 / 16	10 / 16	83	84	1.092	148.866	+ 0.2096*	+ 0.2134*	+0.2115	−3.8	−16.2	+54.6061
5	9	84	85	1.206	150.072	+ 3.1168	+ 3.1153	+3.1160	+1.5	−14.7	+57.7221
7	9	85	86	1.173	151.245	− 2.0617	− 2.0644	−2.0630	+2.7	−12.0	+55.6591
7	9	86	87	1.162	152.407	+ 2.0910	+ 2.0887	+2.0898	+2.3	− 9.7	+57.7489
7	9	87	88	1.196	153.603	+ 0.9474	+ 0.9505	+0.9490	−3.1	−12.8	+58.6979
7	9	88	89	0.394	153.997	− 1.2345	− 1.2359	−1.2352	+1.4	−11.4	+57.4627
8	9	89	90	1.270	155.267	− 0.6065	− 0.6040	−0.6052	−2.5	−13.9	+56.8575
8	9	90	91	1.225	156.492	+ 3.2818	+ 3.2807	+3.2813	+1.1	−12.8	+60.1388
11		91	N_2	0.135	156.627	+ 1.1912	+ 1.1914	+1.1913	−0.2	−13.0	+61.3301
12	15	91	92	1.152	157.644	− 2.1247	− 2.1274	−2.1260	+2.7	−10.1	+58.0128
12	15	92	93	1.118	158.762	+ 0.5979	+ 0.5988	+0.5984	−0.9	−11.0	+58.6112
12	15	93	94	1.100	159.862	+ 2.2641	+ 2.2634	+2.2638	+0.7	−10.3	+60.8750
12	15	94	95	1.102	160.964	− 1.6225	− 1.6221	−1.6223	−0.4	−10.7	+59.2527
12	15	95	96	1.154	162.118	+ 2.4674	+ 2.4672	+2.4673	+0.2	−10.5	+61.7200
12 / 22	15 / 22	96	97	1.599	163.717	− 1.4620*	− 1.4652*	−1.4636	+3.2	− 7.3	+60.2564
17	21	97	98	1.138	164.855	+ 0.7759	+ 0.7714	+0.7736	+4.5	− 2.8	+61.0300
17	21	98	99	1.066	165.921	+ 2.5397	+ 2.5373	+2.5385	+2.4	− 0.4	+63.5685
17 / 22	21 / 22	99	100	1.038	166.959	+ 0.4904*	+ 0.4896*	+0.4900	+0.8	+ 0.4	+64.0585

*Wherever the asterisk (*) is appended, the result given is the mean of two determinations.

***Results from geodetic spirit-leveling in Alabama and Mississippi*, 1884–'87, *etc.*—Continued.**

SECTION II.—FROM CITRONELLE, ALA., TO QUITMAN, MISS.—Continued.

Date, 1887.		Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Direction of line. Forwards.	Backwards.	Mean.	Discrepancy. Partial. F.-B.	Total accumulated.	Height of mark above average Gulf level (at Biloxi, Miss.).
Mar.				*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
17	21	100	101	1.122	168.081	— 1.4142	— 1.4137	—1.4140	—0.5	— 0.1	+62.6445
17	21	101	102	1.174	169.255	+ 0.9014	+ 0.8978	+0.8996	+3.6	+ 3.5	+63.5441
19		102	O_2	0.217	169.472	— 0.1443	— 0.1439	—0.1441	—0.4	+ 3.1	+63.4000
17	19	102	103	1.176	170.431	+ 2.2285	+ 2.2257	+2.2271	+2.8	+ 6.3	+65.7712
18	19	103	104	1.114	171.545	+ 1.4249	+ 1.4221	+1.4235	+2.8	+ 9.1	+67.1947
18	19	104	105	1.073	172.618	+ 3.1245	+ 3.1260	+3.1252	—1.5	+ 7.6	+70.3199
18, 23	19	105	106	1.372	173.990	— 5.5542*	— 5.5520*	—5.5531	—2.2	+ 5.4	+64.7668
18, 23	19, 23	106	107	1.197	175.187	+ 1.7553*	+ 1.7608*	+1.7580	—5.5	— 0.1	+66.5248
18	19	107	D_2	1.447	176.634	+ 3.5634	+ 3.5662	+3.5648	—2.8	— 2.9	+70.0896
21		D_2	C_2	(See Section III.)							

SECTION III.—FROM QUITMAN TO MERIDIAN, MISS.

[April to May, 1886; J. B. Weir, observer; instrument, geodetic micrometer level No. 3; method, two independent (forward and backward) lines].

Date.		From	To	Distance between successive bench-marks.	Distance from initial mark.	Forwards.	Backwards.	Mean.	Partial. F.-B.	Total accumulated.	Height of mark above average Gulf level.
			D_2	----	176.634	--------	--------	------	----	— 2.9	+70.0896
May 12, 1886; Mar. 24, 1887		D_2	239	0.200	176.834	— 0.0806*	— 0.0806*	—0.0806	0.0	— 2.9	+70.0090
May 11, 1886; Mar. 24, 1887		239	C_2	0.322	------	+ 0.8802*	+ 0.8792*	+0.8797	+1.0	-----	+70.8887
Mar. 21, 1887		D_2	C_2	0.276	176.910	+ 0.7991	+ 0.7998	+0.7994	—0.7	— 3.6	+70.8890
			C_2	----	------	--------	--------	-------	----	Mean.	+70.8888
1886. May.											
12	11	239	238	0.731	177.565	— 0.7116	— 0.7119	—0.7118	+0.3	— 2.6	+69.2972
12	11	238	237	1.090	178.655	— 0.4198	— 0.4244	—0.4221	+4.6	+ 2.0	+68.8751
12	11	237	229	1.078	179.733	— 0.1756	— 0.1790	—0.1773	+3.4	+ 5.4	+68.6978
5	11	229	230	0.729	180.462	+ 0.2880	+ 0.2867	+0.2874	+1.3	+ 6.7	+68.9852
5	11	230	231	1.070	181.532	— 0.6281	— 0.6276	- 0.6278	—0.5	+ 6.2	+68.3574
5	10	231	232	1.066	182.598	+ 0.7461	+0.7449	+0.7455	+1.2	+ 7.4	+69.1029
5	10	232	233	1.435	184.033	— 0.0766	—0.0772	—0.0769	+0.6	+ 8.0	+69.0260
6	10	233	234	1.070	185.103	+ 0.4232	+0.4269	+0.4250	—3.7	+ 4.3	+69.4510
6	8	234	235	1.100	186.203	+ 0.4183	+0.4177	+0.4180	+0.6	+ 4.9	+69.8690
6	8	235	236	1.108	187.311	+ 1.0971	+1.0966	+1.0968	+0.5	+ 5.4	+70.9658
8, 12	8, 12	236	228	0.960	188.271	— 0.0090*	—0.0140*	—0.0115	+5.0	+10.4	+70.9543
4		228	227	1.068	189.339	+ 0.3698	+0.3679	+0.3688	+1.9	+12.3	+71.3231
4		227	226	0.903	190.242	+ 1.9875	+1.9855	+1.9865	+2.0	+14.3	+73.3096
4		226	225	1.182	191.424	+ 0.1622	+0.1625	+0.1624	—0.3	+14.0	+73.4720

* Wherever the asterisk (*) is appended, the result given is the mean of two determinations.

Results from geodetic spirit-leveling in Alabama and Mississippi, 1884–'87, etc.—Continued.

SECTION III.—FROM QUITMAN TO MERIDIAN, MISS.—Continued.

Date, 1886.	Bench-marks.		Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks.			Discrepancy.		Height of mark above average Gulf level (at Biloxi, Miss.).
	From	To			Direction of line. Forwards.	Direction of line. Backwards.	Mean.	Partial. F.–B.	Total accumulated.	
May.			*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
3	225	224	0.895	192.319	−0.0842	−0.0821	−0.0832	−2.1	+11.9	+73.3888
3	224	223	0.722	193.041	+2.7734	+2.7724	+2.7729	+1.0	+12.9	+76.1617
3	223	222	1.120	194.161	−3.0273	−3.0288	−3.0280	+1.5	+14.4	+73.1337
5	222	B_2	0.084	194.245	+1.6551	+1.6557	+1.6554	−0.6	+13.8	+74.7891
Apr.										
29	222	221	0.754	194.915	+1.1393	+1.1372	+1.1382	+2.1	+16.5	+74.2719
29 28	221	220	1.156	196.071	+2.4096	+2.4080	+2.4088	+1.6	+18.1	+76.6807
29 28	220	219	1.124	197.195	−0.7463	−0.7468	−0.7466	+0.5	+18.6	+75.9341
29 28	219	218	1.106	198.301	+2.0305	+2.0311	+2.0308	−0.6	+18.0	+77.9649
29 28	218	217	1.222	199.523	+0.8012	+0.8024	+0.8018	−1.2	+16.8	+78.7667
30 28 30 30	217	216	1.204	200.727	+2.5735*	+2.5764*	+2.5750	−2.9	+13.9	+81.3417
30 26	216	215	1.244	201.971	+0.3036	+0.3040	+0.3038	−0.4	+13.5	+81.6455
24	215	214	0.719	202.690	−0.6918	−0.6903	−0.6910	−1.5	+12.0	+80.9545
24	214	213	1.104	203.794	−0.2343	−0.2346	−0.2344	+0.3	+12.3	+80.7201
24	213	212	1.172	204.966	+0.0934	+0.0957	+0.0946	−2.3	+10.0	+80.8147
23	212	211	0.690	205.656	+0.3762	+0.3750	+0.3756	+1.2	+11.2	+81.1903
23	211	210	1.066	206.722	+0.4002	+0.4036	+0.4019	−3.4	+7.8	+81.5922
23	210	209	1.164	207.886	+0.9285	+0.9251	+0.9268	+3.4	+11.2	+82.5190
22	209	208	1.079	208.965	+1.8368	+1.8353	+1.8360	+1.5	+12.7	+84.3550
22	208	205	1.218	210.183	+0.7225	+0.7281	+0.7253	−5.6	+7.1	+85.0803
21	205	206	1.231	211.414	+0.7088	+0.7102	+0.7095	−1.4	+5.7	+85.7898
21	206	207	1.138	212.552	+1.3908	+1.3915	+1.3912	−0.7	+5.0	+87.1810
21	207	204	0.679	213.231	+1.2661	+1.2630	+1.2646	+3.1	+8.1	+88.4456
20	204	203	0.701	213.932	+0.8273	+0.8248	+0.8260	+2.5	+10.6	+89.2716
20	203	202	1.090	215.022	+2.7737	+2.7701	+2.7719	+3.6	+14.2	+92.0435
20	202	201	1.167	216.189	+1.2011	+1.1988	+1.2000	+2.3	+16.5	+93.2435
19	201	200	0.715	216.904	+0.5418	+0.5412	+0.5415	+0.6	+17.1	+93.7850
19	200	199	1.051	217.955	+4.0720	+4.0720	+4.0720	0.0	+17.1	+97.8570
19	199	198	0.758	218.713	+4.1427	+4.1408	+4.1418	+1.9	+19.0	+101.9988
19	198	C	0.540	219.253	+2.9007	+2.9005	+2.9006	+0.2	+19.2	+104.8994

* Wherever the asterisk (*) is appended, the result given is the mean of two determinations,

Results from geodetic spirit-leveling in Alabama and Mississippi, 1884–'87, etc.—Continued.

SECTION IV. - FROM MERIDIAN TO OKOLONA, MISS.

[March to May, 1884; J. B. Weir, observer; instrument, geodetic micrometer level No. 1; method, two simultaneous parallel lines in one direction.]

Date, 1884.	Bench-marks.		Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks.			Discrepancy.		Height of mark above average Gulf level (at Biloxi, Miss.).
	From	To			Line with Rod E.	Line with Rod F.	Mean.	Partial E.-F.	Total accumulated.	
			Km.	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
Mar.		C†	----	219.253	------	------	------	----	----‡	+104.8994
8	C	D	0.058	219.311	+0.2857	+0.2850	+0.2854	+0.7	+ 0.7	+105.1848
8	C	38	0.926	220.179	− 5.2533	− 5.2534	− 5.2534	+0.1	+ 0.1	+ 99.6460
8	38	39	1.482	221.661	+ 4.1986	+ 4.1972	+ 4.1979	+1.4	+ 1.5	+103.8439
8	39	40	1.746	223.407	− 1.2734	− 1.2732	− 1.2733	−0.2	+ 1.3	+102.5706
10	40	41	1.820	225.227	+ 1.2565	+ 1.2619	+ 1.2592	−5.4	− 4.1	+103.8298
10	41	42	1.770	226.997	+ 6.1911	+ 6.1935	+ 6.1923	−2.4	− 6.5	+110.0221
10	42	43	1.462	228.459	− 0.1464	− 0.1464	− 0.1464	0.0	− 6.5	+109.8757
10	43	44	1.570	230.029	+ 3.7429	+ 3.7466	+ 3.7448	−3.7	−10.2	+113.6205
11	44	45	1.498	231.527	+ 2.3681	+ 2.3656	+ 2.3668	+2.5	− 7.7	+115.9873
11	45	46	1.490	233.017	+ 4.6216	+ 4.6227	+ 4.6222	−1.1	− 8.8	+120.6095
11	46	47	1.520	234.537	+ 7.3092	+ 7.3089	+ 7.3090	+0.3	− 8.5	+127.9185
11	47	48	1.428	235.965	− 6.3940	− 6.3963	− 6.3952	+2.3	− 6.2	+121.5233
11	48	49	1.240	237.205	− 6.1839	− 6.1819	− 6.1829	−2.0	− 8.2	+115.3404
12	49	50	1.530	238.735	− 8.6226	− 8.6273	− 8.6250	+4.7	− 3.5	+106.7154
12	50	51	1.486	240.221	− 8.9344	− 8.9336	− 8.9340	−0.8	− 4.3	+ 97.7814
12	51	52	1.479	241.700	− 7.6758	− 7.6779	− 7.6768	+2.1	− 2.2	+ 90.1046
12	52	53	1.538	243.238	− 5.9639	− 5.9651	− 5.9645	+1.2	− 1.0	+ 84.1401
14	53	54	1.655	244.893	− 9.0512	− 9.0494	− 9.0503	−1.8	− 2.8	+ 75.0898
14	54	55	1.682	246.575	− 7.0997	− 7.1024	− 7.1010	+2.7	− 0.1	+ 67.9888
14	55	56	1.386	247.961	− 2.9748	− 2.9712	− 2.9730	−3.6	− 3.7	+ 65.0158
14	56	57	1.410	249.371	− 1.6991	− 1.6965	− 1.6978	−2.6	− 6.3	+ 63.3180
17	57	58	1.712	251.083	+ 3.6035	+ 3.6014	+ 3.6024	+2.1	− 4.2	+ 66.9204
17	58	59	1.666	252.749	− 4.1345	− 4.1350	− 4.1348	+0.5	− 3.7	+ 62.7856
17	59	60	1.981	254.730	− 0.5060	− 0.5052	− 0.5056	−0.8	− 4.5	+ 62.2800
17	60	61	2.010	256.740	+ 7.9945	+ 7.9911	+ 7.9928	+3.4	− 1.1	+ 70.2728
18	61	62	1.412	258.152	+10.5942	+10.5925	+10.5934	+1.7	+ 0.6	+ 80.8662
18	62	63	1.478	259.630	+ 1.0122	+ 1.0097	+ 1.0110	+2.5	+ 3.1	+ 81.8772
18	63	64	1.496	261.126	− 8.4256	− 8.4265	− 8.4260	+0.9	+ 4.0	+ 73.4512
20	64	65	1.484	262.610	− 8.8894	− 8.8898	− 8.8896	+0.4	+ 4.4	+ 64.5616
20, 24	65	66	1.912	264.522	−10.7770*	−10.7792*	−10.7781	+2.2	+ 6.6	+ 53.7835
20, 24	66	67	1.586	266.108	+ 0.7777*	+ 0.7756*	+ 0.7766	+2.1	+ 8.7	+ 54.5601
20	67	68	1.682	267.790	+ 2.2363	+ 2.2414	+ 2.2388	−5.1	+ 3.6	+ 56.7989
21	68	69	1.722	269.512	+ 3.4375	+ 3.4377	+ 3.4376	−0.2	+ 3.4	+ 60.2365

* Wherever the asterisk (*) is appended, the result given is the mean of two determinations.

† From B. M. C. to B. M. IV was run in the forward direction.

‡ Break in count due to change of method of leveling.

Results from geodetic spirit-leveling in Alabama and Mississippi, 1884–'87, etc.—Continued.

SECTION IV.—FROM MERIDIAN TO OKOLONA, MISS.—Continued.

Date, 1884.	Bench-marks.		Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks.			Discrepancy.		Height of mark above average Gulf level (at Biloxi, Miss.).
	From	To			Line with Rod E.	Line with Rod F.	Mean.	Partial. E.-F.	Total accumulated.	
May			*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
21	69	70	1.939	271.451	+ 6.7424	+ 6.7436	+ 6.7430	−1.2	+ 2.2	+ 66.9795
21	70	71	1.355	272.806	+ 5.9727	+ 5.9689	+ 5.9708	+3.8	+ 6.0	+ 72.9503
21	71	72	1.652	274.458	− 8.2357	− 8.2411	− 8.2384	+5.4	+11.4	+ 64.7119
22	72	73	1.957	276.415	−10.2949	−10.2943	−10.2946	−0.6	+10.8	+ 54.4173
22	73	74	1.308	277.723	+ 0.0981	+ 0.1005	+ 0.0993	−2.4	+ 8.4	+ 54.5166
25 } 31 }	74	75	1.528	279.251	+ 2.2128*	+ 2.2094*	+ 2.2111	+3.4	+11.8	+ 56.7277
25	75	76	1.752	281.003	+ 3.3990	+ 3.4027	+ 3.4008	−3.7	+ 8.1	+ 60.1285
25	76	77	1.486	282.489	− 5.9959	− 6.0013	− 5.9986	+5.4	+13.5	+ 54.1299
25	77	IV	1.931	284.420	+ 2.0532	+ 2.0514	+ 2.0523	+1.8	+15.3	+ 56.1822
31	IV †	94	1.174	285.594	+ 0.8050	+ 0.8060	+ 0.8055	−1.0	+14.3	+ 56.9877
Apr. 1	94	E	0.228	285.822	+ 1.9504	+ 1.9506	+ 1.9505	−0.2	+14.1	+ 58.9382
Mar.										
31	94	93	1.446	287.040	+ 1.8524	+ 1.8516	+ 1.8520	+0.8	+15.1	+58.8397
29	93	92	1.443	288.483	+ 7.0229	+ 7.0259	+ 7.0244	−3.0	+12.1	+65.8641
29	92	91	1.413	289.896	+ 1.6697	+ 1.6754	+ 1.6726	−5.7	+ 6.4	+67.5367
29	91	90	1.404	291.300	− 8.0581	− 8.0600	− 8.0590	+1.9	+ 8.3	+59.4777
29	90	89	1.403	292.703	− 6.4806	− 6.4822	− 6.4814	+1.6	+ 9.9	+52.9963
28	89	88	1.991	294.694	+ 0.3910	+ 0.3938	+ 0.3924	−2.8	+ 7.1	+53.3887
28	88	87	1.457	296.151	+ 3.2541	+ 3.2509	+ 3.2525	+3.2	+10.3	+56.6412
28	87	86	1.376	297.527	+ 4.1484	+ 4.1472	+ 4.1478	+1.2	+11.5	+60.7890
28	86	85	1.395	298.922	+ 4.7849	+ 4.7825	+ 4.7837	+2.4	+13.9	+65.5727
27	85	84	1.697	300.619	+ 5.0804	+ 5.0830	+ 5.0817	−2.6	+11.3	+70.6544
27	84	83	1.367	301.986	− 2.2125	− 2.2117	− 2.2121	−0.8	+10.5	+68.4423
27	83	82	1.667	303.653	− 7.8233	− 7.8228	− 7.8230	−0.5	+10.0	+60.6193
27	82	81	1.456	305.109	+ 4.4009	+ 4.4018	+ 4.4014	−0.9	+ 9.1	+65.0207
26	81	80	1.952	307.061	− 2.6194	− 2.6210	− 2.6202	+1.6	+10.7	+62.4005
26	80	79	1.367	308.428	+ 5.3609	+ 5.3584	+ 5.3596	+2.5	+13.2	+67.7601
26 } Apr. 2 }	79	78	1.379	309.807	− 1.8129*	− 1.8149*	− 1.8139	+2.0	+15.2	+65.9462
Mar. 26	78	V	1.457	311.264	− 9.2438	− 9.2429	− 9.2434	−0.9	+14.3	+56.7028
Apr.										
2	V ‡	95	1.666	312.930	− 4.2534	− 4.2530	− 4.2532	−0.4	+13.9	+52.4496
2	95	VI	1.715	314.645	+ 2.0622	+ 2.0664	+ 2.0643	−4.2	+ 9.7	+54.5139
14	VI §	122	1.788	316.433	− 1.7212	− 1.7198	− 1.7205	−1.4	+ 8.3	+52.7934

* Wherever the asterisk (*) is appended, the result given is the mean of two determinations.
† B. M.'s IV to V were run in the backward direction.
‡ B. M.'s V to VI and 96 were run in the forward direction.
§ B. M.'s VI to 96 were run in the backward direction.

Results from geodetic spirit-leveling in Alabama and Mississippi, 1884–'87, etc.—Continued.

SECTION IV.—FROM MERIDIAN TO OKOLONA, MISS.—Continued.

Date, 1884.	Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Line with Rod E.	Difference of height between bench-marks. Line with Rod F.	Difference of height between bench-marks. Mean.	Discrepancy. Partial E–F.	Discrepancy. Total accumulated.	Height of mark above average Gulf level (at Biloxi, Miss.).
Apr.			*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
14	122	98	1.169	317.602	+ 0.0526	+ 0.0499	+0.0512	+2.7	+11.0	+52.8446
3	98	97	1.368	318.970	+ 0.8512	+ 0.8547	+0.8530	−3.5	+ 7.5	+53.6976
3	97	F.	0.133	319.103	− 0.1731	− 0.1740	−0.1736	+0.9	+ 8.4	+53.5240
3	97	96	1.577	320.547	+ 1.1888	+ 1.1890	+1.1889	−0.2	+ 7.3	+54.8865
7	96 †	106	1.560	322.107	− 0.3132	− 0.3152	−0.3142	+2.0	+ 9.3	+54.5723
7, 12, 18	106	107	1.300	323.407	+ 1.0567§	+ 1.0583§	+1.0575	−1.6	+ 7.7	+55.6298
7	107	108	1.977	325.384	+ 6.0501	+ 6.0478	+6.0490	+2.3	+10.0	+61.6788
12	108 ‡	121	1.444	326.828	+ 8.1088	+ 8.1074	+8.1081	+1.4	+11.4	+69.7869
12	121	120	1.226	328.054	+ 3.8214	+ 3.8240	+3.8227	−2.6	+ 8.8	+73.6096
12	120	119	1.724	329.778	+ 5.2630	+ 5.2638	+5.2634	−0.8	+ 8.0	+78.8730
11	119	118	2.378	332.156	− 0.1415	− 0.1392	−0.1404	−2.3	+ 5.7	+78.7326
10	118	117	1.732	333.888	+ 3.9135	+ 3.9115	+3.9125	+2.0	+ 7.7	+82.6451
10	117	116	1.029	334.917	− 5.3238	− 5.3214	−5.3226	−2.4	+ 5.3	+77.3225
10	116	115	1.581	336.498	+ 6.1875	+ 6.1879	+6.1877	−0.4	+ 4.9	+83.5102
9	115	114	1.465	337.963	+ 9.8981	+ 9.8940	+9.8960	+4.1	+ 9.0	+93.4062
9	114	113	0.975	338.938	+ 0.6973	+ 0.6934	+0.6954	+3.9	+12.9	+94.1016
9	113	112	1.027	339.965	− 0.7322	− 0.7292	−0.7307	−3.0	+ 9.9	+93.3709
9	112	111	1.564	341.529	− 1.9966	− 2.0000	−1.9983	+3.4	+13.3	+91.3726
8	111	110	1.318	342.847	− 0.3828*	− 0.3842*	−0.3835	+1.4	+14.7	+90.9891
8	110	109	0.892	343.739	− 5.2232	− 5.2268	−5.2250	+3.6	+18.3	+85.7641
8	109	105	1.400	345.139	+ 4.3418	+ 4.3394	+4.3406	+2.4	+20.7	+90.1047
5	105	104	2.243	347.382	+ 2.4673	+ 2.4683	+2.4678	−1.0	+19.7	+92.5725
5	104	103	1.467	348.849	− 7.9403	− 7.9414	−7.9408	+1.1	+20.8	+84.6317
5	103	102	1.504	350.353	− 3.1250	− 3.1295	−3.1272	+4.5	+25.3	+81.5045
5	102	101	1.473	351.826	+ 1.3148	+ 1.3182	+1.3165	−3.4	+21.9	+82.8210
4	101	100	1.653	353.479	− 9.0843	− 9.0879	−9.0861	+3.6	+25.5	+73.7349
4	100	99	1.360	354.839	− 3.6866	− 3.6835	−3.6850	−3.1	+22.4	+70.0499
15	99	G	0.359	355.198	+ 1.2547	+ 1.2552	+1.2550	−0.5	+21.9	+71.3049
4, 15	99	VII	1.623	356.462	− 3.3948*	− 3.3990*	−3.3969	+4.2	+26.6	+66.6530
15	VII ‖	123	1.072	357.534	− 3.6195	− 3.6190	−3.6192	−0.5	+26.1	+63.0338
15	123	124	1.150	358.684	− 1.3250	− 1.3284	−1.3267	+3.4	+29.5	+61.7071
15	124	125	1.211	359.895	− 1.4064	− 1 4054	−1.4059	−1.0	+28.5	+60.3012
16	125	126	1.574	361.469	− 1.0210	− 1.0197	−1.0204	−1.3	+27.2	+59.2808

* Wherever the asterisk (*) is appended, the result given is the mean of two determinations.
† B. M.'s 96 to 108 were run in the forward direction.
‡ B. M.'s 108 to VII were run in the backward direction.
§ The mean of three determinations, two forward and one backward.
‖ B. M.'s VII to 133 were run in the forward direction.

Results from geodetic spirit-leveling in Alabama and Mississippi, 1884–'87, *etc.*—Continued.

SECTION IV.—FROM MERIDIAN TO OKOLONA, MISS.—Continued.

Date, 1884.	Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Line with Rod E.	Line with Rod F.	Mean.	Discrepancy. Partial. E.-F.	Total accumulated.	Height of mark above average Gulf level (at Biloxi, Miss.).
Apr.			*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
16	126	127	1.099	362.568	+ 1.6935	+ 1.6913	+1.6924	+2.2	+29.4	+60.9732
16	127	128	1.145	363.713	− 2.0471	− 2.0499	−2.0485	+2.8	+32.2	+58.9247
16	128	129	1.431	365.144	+ 5.1469	+ 5.1454	+5.1462	+1.5	+33.7	+64.0709
17	129	130	1.122	366.266	+ 4.9111	+ 4.9084	+4.9098	+2.7	+36.4	+68.9807
17	130	131	1.028	367.294	− 5.4483	− 5.4484	−5.4484	+0.1	+36.5	+63.5323
17	131	132	1.098	368.392	− 3.1322	− 3.1310	−3.1316	−1.2	+35.3	+60.4007
17	132	133	1.140	369.532	− 4.2155	− 4.2140	−4.2148	−1.5	+33.8	+56.1859
22	133†	137	1.148	370.680	− 0.2598	− 0.2597	−0.2598	−0.1	+33.7	+55.9261
22	137	136	1.260	371.940	+ 0.7576	+ 0.7565	+0.7570	+1.1	+34.8	+56.6831
21	136	135	2.226	374.166	+ 7.1851	+ 7.1827	+7.1839	+2.4	+37.2	+63.8670
21	135	134	1.235	375.401	+ 1.5114	+ 1.5075	+1.5094	+3.9	+41.1	+65.3764
21	134	H	1.178	376.579	+ 7.0185	+ 7.0201	+7.0193	−1.6	+39.5	+72.3957
23	H	I	0.310	376.889	+ 1.5450	+ 1.5459	+1.5454	−0.9	+38.6	+73.9411
22	H‡	138	1.644	378.223	− 2.9693	− 2.9660	−2.9676	−3.3	+36.2	+69.4281
26	138	150	1.174	379.397	+ 6.8230	+ 6.8232	+6.8231	−0.2	+36.0	+76.2512
26	150	151	1.079	380.476	+ 2.5461	+ 2.5457	+2.5459	+0.4	+36.4	+78.7971
26	151	149	1.046	381.522	+ 2.2300	+ 2.2271	+2.2286	+2.9	+39.3	+81.0257
25	149†	148	1.112	382.634	+ 1.0575	+ 1.0581	+1.0578	−0.6	+38.7	+82.0835
25	148	147	1.044	383.678	− 0.3913	− 0.3909	−0.3911	−0.4	+38.3	+81.6924
25	147	146	1.022	384.700	+ 4.6209	+ 4.6173	+4.6191	+3.6	+41.9	+86.3115
25	146	145	1.108	385.808	+ 2.3341	+ 2.3314	+2.3328	+2.7	+44.6	+88.6443
24	145	144	1.722	387.530	− 4.9469	− 4.9448	−4.9458	−2.1	+42.5	+83.6985
24	144	143	1.152	388.682	+ 2.4862	+ 2.4885	+2.4874	−2.3	+40.2	+86.1859
24	143	142	1.610	390.292	+ 4.0929	+ 4.0968	+4.0948	−3.9	+36.3	+90.2807
24	142	141	1.670	391.962	− 0.7818	− 0.7810	−0.7814	−0.8	+35.5	+89.4993
23	141	140	2.782	394.744	+ 3.3202	+ 3.3172	+3.3187	+3.0	+38.5	+92.8180
23	140	139	1.780	396.524	+ 0.3279	+ 0.3276	+0.3278	+0.3	+38.8	+93.1458
23	139	VIII	1.250	397.774	− 0.1980	− 0.1972	−0.1976	−0.8	+38.0	+92.9482
26	VIII§	152	1.632	399.406	+ 0.4720	+ 0.4719	+0.4720	+0.1	+38.1	+93.4202
28	152	153	1.638	401.044	− 5.0073	− 5.0103	−5.0088	+3.0	+41.1	+88.4114
28	153	154	1.442	402.486	− 2.1757	− 2.1732	−2.1744	−2.5	+38.6	+86.2370
28	154	155	1.203	403.689	− 3.4916	− 3.4862	−3.4889	−5.4	+33.2	+82.7481
29	155	156	1.602	405.291	− 0.6079	− 0.6061	−0.6070	−1.8	+31.4	+82.1411
29	156	157	1.594	406.885	+ 7.8438	+ 7.8412	+7.8425	+2.6	+34.0	+89.9836
29	157	158	1.884	408.769	+ 0.2922	+ 0.2947	+0.2934	−2.5	+31.5	+90.2770

† B. M.'s 133 to H and 149 to VIII were run in the backward direction.

‡ B. M.'s H to 149 were run in the forward direction.

§ B. M.'s VIII to K run in the forward direction.

Results from geodetic spirit-leveling in Mississippi and Louisiana—Continued.

SECTION IV.—FROM MERIDIAN TO OKOLONA, MISS.—Continued.

Date, 1884.	Bench-marks.		Distance between successive bench marks.	Distance from initial mark.	Difference of height between bench-marks.			Discrepancy.		Height of mark above average Gulf level (at Biloxi, Miss.).
	From	To			Line with		Mean.	Partial E.-F.	Total accumulated.	
					Rod E.	Rod F.				
			Km.	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
Apr.										
30	158	159	1.117	409.886	+ 3.6743	+ 3.6746	+3.6744	−0.3	+31.2	+93.9514
30	159	160	1.334	411.220	− 4.2102	− 4.2147	−4.2124	+4.5	+35.7	+89.7390
30	160	161	1.334	412.564	+ 4.3439	+ 4.3457	+4.3448	−1.8	+33.9	+94.0838
May.										
2	161	162	1.744	414.308	+ 1.7190	+ 1.7167	+1.7178	+2.3	+36.2	+95.8016
2	162	163	1.714	416.022	− 6.2254	− 6.2250	−6.2252	−0.4	+35.8	+89.5764
2	163	164	2.011	418.033	− 3.9555	− 3.9524	−3.9540	−3.1	+32.7	+85.6224
3	164	165	1.190	419.223	− 1.9458	− 1.9430	−1.9444	−2.8	+29.9	+83.6780
3	165	166	1.648	420.871	+ 4.0250	+ 4.0260	+4.0255	−1.0	+28.9	+87.7035
3	166	167	1.389	422.260	+ 4.3745	+ 4.3726	+4.3736	+1.9	+30.8	+92.0771
5	167	168	0.984	423.244	+ 0.7090	+ 0.7107	+0.7098	−1.7	+29.1	+92.7869
5	168	L	0.230	423.474	+ 0.2802	+ 0.2789	+0.2796	+1.3	+30.4	+93.0665
5	168	K	0.252	423.496	+ 1.8276*	+ 1.8260*	+1.8268	+1.6	+30.7†	+94.6137

* Wherever the asterisk (*) is appended, the result given is the mean of two determinations.
† This is only the total accumulated discrepancy from B. M. C. at Meridian, Miss.

Accuracy of the preceding results for heights.

The observed differences of heights resulting from the forward and backward independent measures of a number of bench-marks in the line of levels, are made the basis, as usual, for the determination of the probable errors of the assigned heights of these marks, and they serve also for a general measure of the accuracy of the whole operation. In the latter case, the average probable error in the resulting difference of heights is referred to the kilometre as the unit of length, and, in accordance with the method of least squares, the probable error of leveling is taken to be proportional to the square root of the length of line, or otherwise expressed, the weight w of a result is inversely proportional to the distance s. Let $d =$ difference in the results from two independent measures, one forward, the other backward, in direction, for any mark at the distance s. It is customary to express d in millimetres and s in kilometres. $n =$ the number of such differences or the number of separate lines making up the whole distance. $m_{,}$ and $m_{,,} =$ the *mean* square error of a *single* leveling and of a *double* leveling, respectively, in one kilometre, or for a unit of length; then

$$m_{,} = \sqrt{\frac{1}{2n}\left[\frac{dd}{s}\right]} \quad \text{and} \quad m_{,,} = \frac{m_{,}}{\sqrt{2}}$$

Putting $r_{,,}$ and r respectively for the probable errors of *double* leveling for a line of unit length (1 kilometre) and of a line of length S, then

$$r_{,,} = 0.675\ m_{,,} \quad \text{and} \quad r = 0.675\ m_{,,}\sqrt{S} \quad \text{or} \quad r_{,,}\sqrt{S}$$

In case the successive marks are distributed over the line with tolerable regularity at distances of one kilometre, and the several parts of the line are about equally adapted to the operation, the above formulæ may be made to take a simpler form, since $w = 1$ nearly, hence, the probable error of a resulting difference of height from a double measure of a length of one kilometre becomes $0.675\sqrt{\frac{[dd]}{4[s]}}$ and, consequently, the probable error for a terminal point at the distance $S = [s]$ will be $r = 0.675\sqrt{\frac{[dd]}{4}}$. In the table below, the results were deduced from the more simple formula.

Bench-marks at— Starting point.	Bench-marks at— Terminal point.	Distance.		$[dd]$	n	$r_{,,}$	r
		Km.	*St. m.*			*Mm.*	*Mm.*
Biloxi, Miss., tidal station.	Mobile, Ala., Custom-House.*	94.30	58.6	454	94	±0.74	± 7.2
Mobile.	Citronelle, Ala.†	53.66	33.3	225	41	±0.86	± 6.3
Citronelle.	Quitman, Miss.	122.97	76.4	668	108	±0.79	± 8.7
Quitman.	Meridian, Miss.	42.62	26.5	101	29	±0.71	± 4.7
Meridian.	Okolona, Miss.†	204.24	126.9	875	138	±0.87	±12.5
	Total from tide-water gauge.	517.79	321.7		Average	±0.81	

* From report on results of spirit-leveling between Mobile and New Orleans; Appendix 9, Report for 1887.

† The mean and probable errors were increased by their fourth part.

For comparison with other lines of levels, we have $m_{,}$ the *mean* error of a *single* leveling of one kilometre, or $m_{,} = \sqrt{\frac{[dd]}{2[s]}}$ when the simplified formula is used:

	Mm.	
Biloxi to Mobile.	±1.55	
Mobile to Citronelle.*	±1.81	
Citronelle to Quitman.	±1.65	±1.69† mm
Quitman to Meridian.	±1.50	
Meridian to Okolona.*	±1.83	

* The mean and probable errors were increased by their fourth part.

† Average value (with consideration of distance).

For comparison, we had for the line Mobile, Ala., to New Orleans, La., 1885–'86, $m_{,} = \pm 1.40^{mm}$, and for the line, Sandy Hook, N. J., to Dobbs' Ferry, N. Y., 1886–'87, $m_{,} = \pm 2.33^{mm}$.

The total resulting probable error of leveling between Biloxi and Okolona is equal to

$$\sqrt{(7.2)^2+(6.3)^2+(8.7)^2+(4.7)^2+(12.5)^2} = \pm 18.5^{mm}.$$

This probable error is less than that adopted for the average tidal level of the Gulf water, which was $\pm 25.0^{mm}$; the probable error of the resulting absolute height of Okolona is therefore $\sqrt{(18.5)^2+(25.0)^2} = \pm 31.1^{mm}$.

The accumulated discrepancies, either between the results by two staves or between the forward and backward measures, remain reasonably small, the maximum amount in each of the four sections being $+10.0$, -32.5, $+22.1$ and $+44.6^{mm}$. In the last case, the gap between the E and F lines of levels just reaches $1\frac{3}{4}$ inches, which is the maximum departure in the whole line.

A description of the principal bench-marks is herewith appended.

Yours, respectfully,

CHAS. A. SCHOTT,
Assistant in charge Computing Division.

Mr. B. A. COLONNA,
Assistant in charge Office and Topography.

SECTION I.—*Location and description of permanent bench-marks between Mobile and Citronelle, Ala.*

A.—On custom-house at Mobile, Ala. The bottom of a square cavity cut in the window-sill on the southeast corner of the building; the window fronts on St. Francis street, and is the first one north of Royal street.

Astronomical Station.—At Mobile, Ala. Old hydrographic bench-mark at old astronomical station in Bienville Park.

B.—At Citronelle, Ala. The center of cross on head of copper bolt leaded horizontally in the south chimney of the cottage belonging to the Mobile and Ohio Railroad. The bolt is in the middle of the brick in the fourth layer from the ground, three bricks from east edge of chimney and three from the west edge.

SECTION II.—*Location and description of permanent bench-marks from Citronelle, Ala., to Quitman, Miss.*

B.—Described in Section I.

E_2.—At mile-post 38 of the Mobile and Ohio Railroad, in Washington County, Ala. The bottom of square cavity cut in top of marking stone set in the ground on the east side of the track, 7.78 metres from the center of track and 0.81 metre from the wire fence. The stone is of white marble, 6 by 6 inches on top, and projects about 5 inches above the ground; the cavity is 1 by 1 inch square and one half-inch deep; the bench is marked thus: U. S. B. □ M.

F_2.—At Deer Park, Washington County, Ala. The bottom of a cavity, 1 inch square and one-half inch deep, in a white marble block set in the front yard of Mr. James B. Rawls' residence. This marble block is between the school-house and well, about 6 inches square, and projecting 1 inch above the ground. The bench is marked thus: U. S. B. □ M.

G_2.—At Escatawpa, Washington County, Ala. The center of horizontal cut on copper bolt leaded horizontally into the south chimney of Dr. W. H. Boykin's house, on Main street. This bolt is in the center of the middle brick, in the eleventh layer above the water-table course.

H_2.—At mile-post 58 of the Mobile and Ohio Railroad in Alabama. The bottom of cavity, 1 inch square and one-half inch deep, cut in a white marble block set on the top of a small hill on the east side of track. Distance of stone from center of track, at right angles, is 30.9 metres and 27.5 metres from the mile-post; it is 6 inches square, projecting about an inch above the ground, and is marked thus: U. S. B. □ M.

I_2.—At State Line, Wayne County, Miss. Center of cross on head of copper bolt leaded horizontally into west side of the south chimney of Mr. E. A. Lister's house. This house is on the east side of the Mobile and Ohio Railroad, just opposite the water tank, and is the next one north of Mr. B. A. Cragin's house; the bolt is in the center of the middle brick, in the tenth course above the ground.

J_2.—At Buckatunna, Wayne County, Miss. Center of cross on head of copper bolt leaded horizontally in south chimney of house belonging to Mr. F. H. Hooge. This house is on the west side of the Mobile and Ohio Railroad, about fifty metres S. of railroad station; the bolt is in the center of the middle brick, in the thirteenth course above the water-table course.

K_2.—At Winchester, Wayne County, Miss. Bottom of cavity 1 inch square and one-half inch deep, cut in white marble block set in the front yard near the gate of Mr. A. J. Henderick's house. This marble block is 6 inches square, projects about 4 inches above the ground, and is marked thus: U. S. B. □ M.

L_2.—At Waynesboro, Wayne County, Miss. Center of cross on head of copper bolt leaded horizontally into a brick, on the front side of Mr. J. P. Turner's store on the northeast corner of Car and Station streets. The bolt is in the center of the fifth brick from the south wall, and in the twelfth course above the foundation.

M_2.—At mile-post 89 of the Mobile and Ohio Railroad in Mississippi. Bottom of cavity 1 inch square and one-half inch deep, cut in white marble block set on east side of track. This stone is 11.1 metres, at right angles, from the center of track; is 6 inches square on top, projects about 3 inches above the ground, and is marked thus: U. □ S. B. M.

N_2.—At Shubuta, Clarke County, Miss. Center of cross on head of copper bolt leaded horizontally into the front wall of Mr. M. Greenhood's store, a one-story brick building on the north side of Occutta street, west of the Mobile and Ohio Railroad. The bolt is in the center of a brick, 2½ bricks east of store door and 2½ west of west side of window, in the fourteenth course above the foundation and two courses above lower sill of window.

O_2.—Near railroad station of the Mobile and Ohio Railroad at De Soto, Clarke County, Miss. Bottom of cavity 1 inch square and one-half inch deep, cut in marking stone set in the ground 0.38 metre N. of north wall of station and 1.45 metres W. of the east wall. This stone is a white marble block, about 6 inches square, projecting about 3 inches above the ground, and marked thus: U. □ S. B. M.

D_2.—Near Mobile and Ohio Railroad station at Quitman, Clarke County, Miss. Bottom of square cavity cut in the top of marking stone set in the front yard, on the left side of the gate (as you go in) of Dr. Jere. Sauder's hotel. The stone is about 6 inches square and marked thus: U. □ S. B. M.

Established in May, 1886.

C_2.—On court-house at Quitman, Miss. Described in Section III.

SECTION III.—*Location and description of permanent bench-marks from Quitman to Meridian, Miss.*

D_2.—Described in Section II.

C_2.—On court-house at Quitman, Clarke County, Miss. Center of cross cut on head of copper bolt leaded horizontally in the middle of a brick, on the west face and near the northwest corner of the court-house. The brick is in the fourth layer above the water-table, and second one from north end of pillar at corner of building.

B_2.—At Enterprise, Clarke County, Miss. Center of head of copper bolt, 0.0646 metre in length and 0.0132 metre in diameter, leaded horizontally in the middle of a brick in the north face of Chickasawhay Mills. The brick is in the tenth course above the ground, about half-way between the two main doors of brick structure.

C.—On court-house at Meridian, Lauderdale County, Miss. A cross cut on the iron door-sill at the north entrance. Is near the east edge of the sill and measures, from its center to the extreme N. edge of sill, 0.32 metre and 0.0445 metre from the E. door-jamb. Established March, 1884, and marked thus: **X**.

SECTION IV.—*Location and description of permanent bench-marks from Meridian to Okolona, Miss.*

C.—On court-house at Meridian, Miss. Described in Section III.

D.—At Meridian, Lauderdale County, Miss. Is the upper part of the last stroke in the last "N" in the name of John Stinson inscribed on the granite block placed in the northeast corner of the court-house. This block bears the names of the board of supervisors.

E.—At Scooba, Kemper County, Miss. Center of copper bolt leaded horizontally in the south side of the chimney at the west end of J. H. Duke's store. The bolt is almost in the center of the brick in the eighteenth course from the ground and one brick from the west end of chimney.

F.—Near Macon, Noxubee County, Miss., on the Mobile and Ohio Railroad. A cross cut on the southeast corner of the coping on the south abutment of bridge over Noxubee River. Center of cross measures 0.250 metre from extreme S. edge of stone and 0.220 metre from iron wall-plate resting on stone.

96.—Near Mobile and Ohio Railroad station at Macon, Noxubee County, Miss. A cross on the end of a brick in the south pier of the water tank. Center of cross is 0.0035 metre from extreme S. end of pier and 0.0435 metre from extreme E. end.

G.—At Artesia, Lowndes County, Miss. Center of cross on copper bolt leaded horizontally into a brick in the southwest pier of the hotel at Artesia. The brick is in the third course from the top and one brick from the north end of pier.

H.—At West Point, Clay County, Miss. Bottom of square cavity cut in brick in the top of offset on the east front of the Jackson House. Center of bench to extreme E. edge of brick, measures 0.012 metre.

I.—On court-house at West Point, Clay County, Miss. A point on the granite block or tablet bearing the inscription of Cannon Lodge No. 159, situated in the northeast corner of the court house. There is a horizontal line near the middle of this tablet and the bench is the point directly below the letter "A."

L.—At Mobile and Ohio Railroad station at Okolona, Chickasaw County, Miss. Center of copper bolt leaded horizontally into a brick in the southwest pier of the station. The brick is the middle one on the west side of the pier, and in the seventh layer from the ground.

K.—On cotton warehouse at Okolona, Miss. Center of bolt leaded horizontally in a brick on the east front and near the south end of the warehouse occupied by C. R. Smith. The brick is the thirteenth one south of door and in the twenty-second course from the ground.

APPENDIX No. 11.—1888.

HEIGHTS FROM SPIRIT-LEVELING OF PRECISION BETWEEN NEW ORLEANS, LA., AND WILKERSON'S LANDING, MISS., OPPOSITE ARKANSAS CITY, ARK.

Levelings between Carrollton (New Orleans), La., and Greenville, Miss., executed by O. H. TITTMANN and ANDREW BRAID, Assistants, and J. B. WEIR, Subassistant, 1879–1881. Levelings between Greenville and Wilkerson's Landing, Miss., opposite Arkansas City, Ark., executed under direction of the MISSISSIPPI RIVER COMMISSION by J. B. JOHNSON, Assistant Engineer, 1880–'81.

Report on reduction of observations and results by CHARLES A. SCHOTT, Assistant.

COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE,
December 29, 1888.

The results of spirit-leveling of precision from New Orleans (or Carrollton) up the Mississippi River to Wilkerson's Landing, Miss., are here presented in five sections for convenience of reference.

Respecting description of instruments, their adjustment, and the method of using them, it suffices to refer to Appendices No. 15, Report for 1879, by Assistant Tittmann, and to No. 11, Report for 1880, by Assistant Braid. The field computation was made by the observers, and the office computation by Mr. A. S. Christie and Mr. H. Farquhar; the compilation and reduction to sea-level is due to Mr. L. A. Bauer. Other particulars are given at the head of each section, but for the discussion of the probable errors of the resulting heights for each part and for the whole line from Biloxi, Miss., to Little Rock, Ark., the reader is referred to the next following Appendix No. 12, in which the levels are continued to Little Rock. The route of levels follows the levees of the river and is subdivided as follows:

1. From Carrollton, to Red River Landing, La. The line of levels starts from the bench-mark at Carrollton, which is connected by levels with Biloxi, Miss. and where the average level of the Gulf of Mexico is taken up, follows the eastern bank of the river up to near Baton Rouge, near which place it crosses the Mississippi and continues thence on its western side to Red River Landing. The elevation above the average sea or Gulf level of the Carrollton bench-marks will be found in Appendix No. 9, Report for 1887.

2. From Red River Landing to Biela's Landing, La., opposite Rodney, Miss. The route is along the western side of the river, with a branch line across the river to connect with Fort Adams, Miss.

3. From Biela's Landing to Milliken's Bend, La., above Vicksburg. The line continues on the western side of the river.

4. From Milliken's Bend to Greenville, Miss. The line crosses to the east side at Tennessee Landing below Providence, La., and continues on that side to Greenville.

5. From Greenville to Wilkerson's Landing, Miss., opposite Arkansas City. The route from Greenville lies on the eastern bank and again crosses the river near Arkansas City whence it follows the railroad toward Little Rock, as stated in detail in the next appendix.

SECTION I.—*From Carrollton to Red River Landing, La.*

[Observer, A. Braid; instruments, geodetic micrometer level No. 1, rods A & B; method of observing, two simultaneous lines run in the same direction (alternate *sections* run in opposite directions.)]

Date, 1879–'80.	Bench-marks.		Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks.			Discrepancy.		Height of bench-mark above average Gulf level (at Biloxi, Miss.).
	From	To			Line with Rod A.	Line with Rod B.	Mean.	Partial "A"–"B."	Total.	
1879.			*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
Dec.		I	----	0. 000	------	------	------	------	0. 0	+2. 6659*
29	I	Hampson† (Williams).	0. 116	------	—0. 2056	—0. 2048	—0. 2052	— 0. 8	------	+2. 4607
29	I	E. B. 1	0. 070	0. 070	+2. 1192	+2. 1203	+2. 1198	— 1. 1	— 1. 1	+4. 7857
27	E. B. 1	E. B. 2	0. 122	0. 192	+0. 3710	+0. 3733	+0. 3721	— 2. 3	— 3. 4	+5. 1578
27	E. B. 2	E. B. 3	0. 122	0. 314	—0. 4939	—0. 4943	—0. 4941	+ 0. 4	— 3. 0	+4. 6637
27	E. B. 3	2d B.	1. 724	2. 038	+0. 4013	+0. 4010	+0. 4012	+ 0. 3	— 2. 7	+5. 0649
31	2d B.	E. 13	2. 323	4. 361	+0. 1554	+0. 1571	+0. 1563	— 1. 7	— 4. 4	+5. 2212
31	E. 13	E. 9	0. 305	4. 666	+0. 1105	+0. 1138	+0. 1122	— 3. 3	— 7. 7	+5. 3334
31	E. 9	E. 8	0. 306	4. 972	+0. 0189	+0. 0179	+0. 0184	+ 1. 0	— 6. 7	+5. 3518
31	E. 8	E. 7	0. 304	5. 276	—0. 3115	—0. 3111	—0. 3113	— 0. 4	— 7. 1	+5. 0405
31	E. 7	E. 6	0. 309	5. 585	—0. 1003	—0. 0997	—0. 1000	— 0. 6	— 7. 7	+4. 9405
1880.										
Jan.										
2	E. 6	E. 5	0. 306	5. 891	—0. 1760	—0. 1784	—0. 1772	+ 2. 4	— 5. 3	+4. 7633
2	E. 5	E. 4	0. 312	6. 203	—0. 4849	—0. 4817	—0. 4833	— 3. 2	— 8. 5	+4. 2800
2	E. 4	E. 3	0. 312	6. 515	+0. 6614	+0. 6604	+0. 6609	+ 1. 0	— 7. 5	+4. 9409
2	E. 3	E. 2	0. 304	6. 819	—0. 0305	—0. 0302	—0. 0304	— 0. 3	— 7. 8	+4. 9105
2	E. 2	E. 1	0. 306	7. 125	+0. 1948	+0. 1954	+0. 1951	— 0. 6	— 8. 4	+5. 1056
2	E. 1	E. 0	0. 305	7. 430	—0. 1428	—0. 1426	—0. 1427	— 0. 2	— 8. 6	+4. 9629
2	E. 0	II	2. 076	9. 506	+0. 6235	+0. 6258	+0. 6247	— 2. 3	—10. 9	+5. 5876
6	II	4	1. 626	11. 132	—1. 2421	—1. 2320	—1. 2370	—10. 1	—21. 0	+4. 3506
6	4	5	2. 250	13. 382	+0. 6975	+0. 6999	+0. 6987	— 2. 4	—23. 4	+5. 0493
6	5	6	2. 148	15. 530	+0. 9515	+0. 9513	+0. 9514	+ 0. 2	—23. 2	+6. 0007
7	6	8	0. 498	16. 028	—0. 6693	—0. 6662	—0. 6677	— 3. 1	—26. 3	+5. 3330
8	8	III	0. 115	16. 143	—2. 0041	—2. 0048	—2. 0044	+ 0. 7	—25. 6	+3. 3286
7	8	7	0. 325	16. 353	—0. 0954	—0. 0978	—0. 0966	+ 2. 4	—23. 9	+5. 2364
7	7	3	1. 795	18. 148	+0. 2200	+0. 2278	+0. 2239	— 7. 8	—31. 7	+5. 4603
5	3	2	3. 067	21. 215	+0. 0251	+0. 0307	+0. 0279	— 5. 6	—37. 3	+5. 4882
5	2	1	2. 047	23. 262	—0. 0264	—0. 0216	—0. 0240	— 4. 8	—42. 1	+5. 4642
5	1	IV	0. 274	23. 536	—0. 1299	—0. 1296	—0. 1298	— 0. 3	—42. 4	+5. 3344
9	IV	10	1. 634	25. 170	—0. 0906	—0. 0879	—0. 0892	— 2. 7	—45. 1	+5. 2452
9	10	9	2. 252	27. 422	+0. 1992	+0. 1967	+0. 1980	+ 2. 5	—42. 6	+5. 4432
9	9	V	2. 135	29. 557	—0. 6816	—0. 6758	—0. 6787	— 5. 8	—48. 4	+4. 7645
10	V	11	1. 910	31. 467	+0. 6259	+0. 6240	+0. 6249	+ 1. 9	—46. 5	+5. 3894

* For the source of this value, see Appendix 9, C. S. Report for 1887. Mark on door-sill of Babcock Engine House, Carrollton.
† See description of bench-marks.

SECTION I.—*From Carrollton to Red River Landing, La.*—Continued.

Date, 1880.	Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Line with Rod A.	Line with Rod B.	Mean.	Discrepancy. Partial "A"-"B."	Discrepancy. Total.	Height of bench-mark above average Gulf level (at Biloxi, Miss.).
Jan.			*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
10	11	12	2.397	33.864	+0.3315	+0.3345	+0.3330	− 3.0	−49.5	+5.7224
10	12	13	1.877	35.741	−1.0505	−1.0458	−1.0482	− 4.7	−54.2	+4.6742
13	13	VI	0.139	35.880	−0.4857	−0.4846	−0.4851	− 1.1	−55.3	+4.1891
14	13	14	1.937	37.678	+1.3476	+1.3500	+1.3488	− 2.4	−56.6	+6.0230
14	14	15	2.669	40.347	+0.0307	+0.0269	+0.0288	+ 3.8	−52.8	+6.0518
14	15	16	3.041	43.388	−0.2743	−0.2728	−0.2736	− 1.5	−54.3	+5.7782
15	16	VII	0.320	43.708	−0.9498	−0.9490	−0.9494	− 0.8	−55.1	+4.8288
15	VII	17	1.493	45.201	+1.8751	+1.8790	+1.8771	− 3.9	−59.0	+6.7059
15	17	18	2.137	47.338	−0.5082	−0.5057	−0.5069	− 2.5	−61.5	+6.1990
15	18	19	0.554	47.892	−0.9940	−0.9970	−0.9955	+ 3.0	−58.5	+5.2035
17 and 19	19	23	0.328	48.220	+0.8871*	+0.8847*	+0.8859	+ 2.4	−56.1	+6.0894
17	23	22	2.922	51.142	+0.5264	+0.5220	+0.5242	+ 4.4	−51.7	+6.6136
17	22	21	2.623	53.765	−0.3759	−0.3699	−0.3729	− 6.0	−57.7	+6.2407
17	21	20	2.251	56.016	+0.0427	+0.0498	+0.0462	− 7.1	−64.8	+6.2869
22	20	VIII	0.165	56.181	−1.3904	−1.3920	−1.3912	+ 1.6	−63.2	+4.8957
22	VIII	27	2.270	58.451	+1.5161	+1.5203	+1.5182	− 4.2	−67.4	+6.4139
22	27	IX	2.631	61.082	+0.2469	+0.2462	+0.2466	+ 0.7	−66.7	+6.6605
22	IX	26	0.871	61.953	−0.3541	−0.3528	−0.3534	− 1.3	−68.0	+6.3071
21	26	25	3.462	65.415	+0.1775	+0.1846	+0.1810	− 7.1	−75.1	+6.4881
20	25	24	3.245	68.660	+0.4266	+0.4250	+0.4258	+ 1.6	−73.5	+6.9139
20	24	X	1.576	70.236	−1.4179	−1.4231	−1.4205	+ 5.2	−68.3	+5.4934
27	X	28	0.261	70.497	+1.6656	+1.6641	+1.6649	+ 1.5	−66.8	+7.1583
27	28	29	2.293	72.790	−0.2779	−0.2740	−0.2760	− 3.9	−70.7	+6.8823
27	29	30	2.837	75.627	+0.3792	+0.3814	+0.3803	− 2.2	−72.9	+7.2626
27	30	31	2.564	78.191	+0.2442	+0.2406	+0.2424	+ 3.6	−69.3	+7.5050
28	31	32	1.485	79.676	−0.5582	−0.5666	−0.5624	+ 8.4	−60.9	+6.9426
28	32	33	2.587	82.263	+0.2435	+0.2360	+0.2398	+ 7.5	−53.4	+7.1824
28	33	XI	0.246	82.509	−0.1704	−0.1689	−0.1696	− 1.5	−54.9	+7.0128
30	33	35	0.787	83.050	+0.2563	+0.2560	+0.2561	+ 0.3	−53.1	+7.4385
30	35	36	0.728	83.778	+0.0815	+0.0816	+0.0816	− 0.1	−53.2	+7.5201
30	36	XII	0.304	84.082	−1.6825	−1.6849	−1.6837	+ 2.4	−50.8	+5.8364
30	36	34	0.646	84.424	+0.0826	+0.0776	+0.0801	+ 5.0	−48.2	+7.6002
31	34	37	1.365	85.789	−0.1650	−0.1635	−0.1642	− 1.5	−49.7	+7.4360
31	37	38	0.859	86.648	+0.0080	+0.0144	+0.0112	− 6.4	−56.1	+7.4472
Feb.										
3	38	39	1.104	87.752	−0.6329	−0.6284	−0.6307	− 4.5	−60.6	+6.8165
3	39	XIII	0.657	88.409	+1.0795	+1.0810	+1.0802	− 1.5	−62.1	+7.8967

* Mean of two determinations.

SECTION I.—*From Carrollton to Red River Landing, La.*—Continued.

Date, 1880.	Bench-marks.		Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks.			Discrepancy.		Height of bench-mark above average Gulf level (at Biloxi, Miss.).
					Line with		Mean.	Partial "A − B."	Total.	
	From	To			Rod A.	Rod B.				
Feb.			*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
3	39	40	1. 216	88. 968	+0. 0658	+0. 0635	+0. 0646	+ 2. 3	−58. 3	+6. 8811
3	40	41	1. 198	90. 166	−0. 0884	−0. 0913	−0. 0898	+ 2. 9	−55. 4	+6. 7913
4	41	42	1. 240	91. 406	+0. 0881	+0. 0840	+0. 0860	+ 4. 1	−51. 3	+6. 8773
4	42	XIV	0. 199	91. 605	+0. 4317	+0. 4311	+0. 4314	+ 0. 6	−50. 7	+7. 3087
4	42	43	1. 978	93. 384	+0. 7160	+0. 7167	+0. 7163	− 0. 7	−52. 0	+7. 5936
4	43	44	1. 073	94. 457	+0. 0953	+0. 0976	+0. 0964	− 2. 3	−54. 3	+7. 6900
6	44	45	1. 796	96. 253	−0. 0185	−0. 0202	−0. 0194	+ 1. 7	−52. 6	+7. 6706
6	45	XV	1. 700	97. 953	−0. 5604	−0. 5592	−0. 5598	− 1. 2	−53. 8	+7. 1108
6	XV	46	1. 282	99. 235	+0. 5429	+0. 5460	+0. 5445	− 3. 1	−56. 9	+7. 6553
7	46	47	1. 206	100. 441	−0. 1558	−0. 1606	−0. 1582	+ 4. 8	−52. 1	+7. 4971
7	47	48	1. 285	101. 726	−1. 0820	−1. 0827	−1. 0824	+ 0. 7	−51. 4	+6. 4147
7	48	49	2. 408	104. 134	+1. 0597	+1. 0599	+1. 0598	− 0. 2	−51. 6	+7. 4745
7	49	50	0. 866	105. 000	+0. 4144	+0. 4168	+0. 4156	− 2. 4	−54. 0	+7. 8901
10	50	XVI	1. 276	106. 276	−0. 3525	−0. 3532	−0. 3529	+ 0. 7	−53. 3	+7. 5372
10	XVI	51	0. 451	106. 727	+0. 5226	+0. 5209	+0. 5217	+ 1. 7	−51. 6	+8. 0589
11	51	52	1. 811	108. 538	−0. 1214	−0. 1265	−0. 1244	+ 4. 1	−47. 5	+7. 9345
11	52	53	1. 448	109. 986	−0. 8063	−0. 8097	−0. 8080	+ 3. 4	−44. 1	+7. 1265
12	53	54	2. 187	112. 173	−0. 4540	−0. 4599	−0. 4569	+ 5. 9	−38. 2	+6. 6696
12	54	55	2. 131	114. 304	+0. 9884	+0. 9910	+0. 9897	− 2. 6	−40. 8	+7. 6593
13	55	56	1. 769	116. 073	+0. 7699	+0. 7662	+0. 7680	+ 3. 7	−37. 1	+8. 4273
13	56	57	1. 591	117. 664	−0. 3512	−0. 3477	−0. 3494	− 3. 5	−40. 6	+8. 0779
13	57	58	1. 502	119. 166	+0. 1771	+0. 1721	+0. 1746	+ 5. 0	−35. 6	+8. 2525
19	58	XVII	0. 181	119. 347	−1. 7117	−1. 7131	−1. 7124	+ 1. 4	−34. 2	+6. 5401
19	XVII	63	1. 809	121. 156	+0. 6828	+0. 6860	+0. 6844	− 3. 2	−37. 4	+7. 2245
24	63	67	1. 296	122. 452	+0. 7858	+0. 7923	+0. 7890	− 6. 5	−43. 9	+8. 0135
24	67	66	2. 079	124. 531	+0. 0484	+0. 0526	+0. 0505	− 4. 2	−48. 1	+8. 0640
23	66	XVIII	0. 364	124. 895	−2. 0266	−2. 0241	−2. 0254	− 2. 5	−50. 6	+6. 0386
23	XVIII	65	1. 799	126. 694	+2. 2722	+2. 2760	+2. 2741	− 3. 8	−54. 4	+8. 3127
23	65	62	1. 797	128. 491	−0. 9542	−0. 9509	−0. 9525	− 3. 3	−57. 7	+7. 3602
18	62	XIX	0. 960	129. 451	+2. 0744	+2. 0754	+2. 0749	− 1. 0	−58. 7	+9. 4351
18	XIX	61	1. 321	130. 772	−2. 3341	−2. 3370	−2. 3356	+ 2. 9	−55. 8	+7. 0995
17	61	60	2. 296	133. 068	+1. 7971	+1. 7957	+1. 7964	+ 1. 4	−54. 4	+8. 8959
17	60	59	2. 198	135. 266	−0. 0087	−0. 0133	−0. 0110	+ 4. 6	−49. 8	+8. 8849
14	59	XX	1. 280	136. 546	−1. 7370	−1. 7388	−1. 7379	+ 1. 8	−48. 0	+7. 1470
25	XX	69	1. 274	137. 820	−0. 1154	−0. 1148	−0. 1151	− 0. 6	−48. 6	+7. 0319
25	69	70	3. 226	141. 046	+1. 7586	+1. 7588	+1. 7587	− 0. 2	−48. 8	+8. 7906
27	70	71	2. 151	143. 197	−0. 9227	−0. 9198	−0. 9213	− 2. 9	−51. 7	+7. 8693
27	71	72	1. 501	144. 698	+0. 9435	+0. 9412	+0. 9423	+ 2. 3	−49. 4	+8. 8116
28	72	XXI	0. 291	144. 989	−0. 7492	−0. 7470	−0. 7481	− 2. 2	−51. 6	+8. 0635
28	XXI	73	2. 181	147. 170	−1. 4581	−1. 4631	−1. 4606	+ 5. 0	−46. 6	+6. 6029

SECTION I.—*From Carrollton to Red River Landing, La.*—Continued.

Date, 1880.	Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Line with Rod A.	Difference of height between bench-marks. Line with Rod B.	Difference of height between bench-marks. Mean.	Discrepancy. Partial "A"–"B."	Discrepancy. Total.	Height of bench-mark above average Gulf level (at Biloxi, Miss.).
Feb.			*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
28	73	XXII	1. 335	148. 505	+1. 3159	+1. 3103	+1. 3131	+ 5. 6	—41. 0	+ 7. 9160
28	XXII	74	1. 512	150. 017	+1. 4183	+1. 4183	+1. 4183	0. 0	—41. 0	+ 9. 3343
Mar.										
3	74	80	2. 447	152. 464	+0. 0159	+0. 0119	+0. 0139	+ 4. 0	—37. 0	+ 9. 3482
3	80	79	1. 629	154. 093	—1. 3054	—1. 3032	—1. 3043	— 2. 2	—39. 2	+ 8. 0439
2	79	XXIII	0. 087	154. 180	—1. 0665	—1. 0661	—1. 0663	— 0. 4	—39. 6	+ 6. 9776
2	XXIII	78	0. 665	154. 845	+2. 7394	+2. 7375	+2. 7385	+ 1. 9	—37. 7	+ 9. 7161
2	78	77	0. 956	155. 801	—0. 0097	—0. 0073	—0. 0085	— 2. 4	—40. 1	+ 9. 7076
2	77	76	1. 694	157. 495	+0. 0300	+0. 0296	+0. 0298	+ 0. 4	—39. 7	+ 9. 7374
2	76	75	1. 569	159. 064	—0. 0708	—0. 0656	—0. 0682	— 5. 2	—44. 9	+ 9. 6692
1	75	XXIV	1. 841	160. 905	—1. 7829	—1. 7840	—1. 7835	+ 1. 1	—43. 8	+ 7. 8857
6	XXIV*	83	0. 127	161. 032	+0. 4557	+0. 4545	+0. 4551	+ 1. 2	—42. 6	+ 8. 3408
6	83	XXV	3. 085	164. 117	+0. 0902	+0. 0904	+0. 0903	— 0. 2	—42. 8	+ 8. 4311
6 and 5	XXV	82	1. 472	165. 589	+0. 8763	+0. 8678	+0. 8721	+ 8. 5	—34. 3	+ 9. 3032
9 and 5	82	81	2. 758	168. 347	+0. 2107	+0. 2135	+0. 2121	— 2. 8	—37. 1	+ 9. 5153
9 and 5	81	XXVI*	3. 138	171. 485	—0. 5218	—0. 5294	—0. 5256	+ 7. 6	—29. 5	+ 8. 9897
17	XXVI	XXVII	5. 636	177. 121	+0. 3433	+0. 3370	+0. 3401	+ 6. 3	—23. 2	+ 9. 3298
11	XXVII	86	0. 551	177. 672	+1. 3295	+1. 3331	+1. 3313	— 3. 6	—26. 8	+10. 6611
11	86	85	1. 575	179. 247	—0. 1273	—0. 1242	—0. 1257	— 3. 1	—29. 9	+10. 5354
11	85	84	1. 466	180. 713	+0. 5489	+0. 5505	+0. 5497	— 1. 6	—31. 5	+11. 0851
11	84	XXVIII	1. 732	182. 445	—1. 9141	—1. 9161	—1. 9151	+ 2. 0	—29. 5	+ 9. 1700
16	XXVIII	91	2. 011	184. 456	+1. 5305	+1. 5273	+1. 5289	+ 3. 2	—26. 3	+10. 6989
16	91	XXIX	1. 113	185. 569	—2. 3162	—2. 3131	—2. 3147	— 3. 1	—29. 4	+ 8. 3842
16	XXIX	90	0. 566	186. 135	+3. 1064	+3. 1043	+3. 1054	+ 2. 1	—27. 3	+11. 4896
13	90	XXX	1. 192	187. 327	—2. 9488	—2. 9498	—2. 9493	+ 1. 0	—26. 3	+ 8. 5403
13	XXX	87	1. 769	189. 096	+1. 8755	+1. 8792	+1. 8773	— 3. 7	—30. 0	+10. 4176
12	87	XXXI	0. 343	189. 439	+8. 4135	+8. 4128	+8. 4131	+ 0. 7	—29. 3	+18. 8307
19	87	94	0. 074	189. 170	+0. 2754	+0. 2749	+0. 2751	+ 0. 5	—29. 5	+10. 6927
19, 22, 24	94	95†	0. 890	190. 060	—1. 3683	—1. 3683	—1. 3683	0. 0	—29. 5	+ 9. 3244
19	95	XXXII	0. 436	190. 496	—0. 8405	—0. 8400	—0. 8403	— 0. 5	—30. 0	+ 8. 4841
19	XXXII	97	2. 960	193. 456	+2. 3935	+2. 3965	+2. 3950	— 3. 0	—33. 0	+10. 8791
20	97	93	3. 500	196. 956	—1. 2018	—1. 2085	—1. 2052	+ 6. 7	—26. 3	+ 9. 6739
18	93	92	1. 762	198. 718	+1. 5666	+1. 5677	+1. 5671	— 1. 1	—27. 4	+11. 2410
18	92	XXXIII	2. 991	201. 709	—2. 0752	—2. 0650	—2. 0701	—10. 2	—37. 6	+ 9. 1709
23	XXXIII	98	2. 975	204. 684	+2. 3575	+2. 3572	+2. 3574	+ 0. 3	—37. 3	+11. 5283
23	98	99	4. 073	208. 757	+0. 2526	+0. 2562	+0. 2544	— 3. 6	—40. 9	+11. 7827
25	99	XXXIV	1. 214	209. 971	—2. 3599	—2. 3560	—2. 3579	— 3. 9	—44. 8	+ 9. 4248
25	XXXIV	100	2. 528	212. 499	+2. 5559	+2. 2459	+2. 2509	+10. 0	—34. 8	+11. 6757
26	100	101	3. 053	215. 552	+0. 5272	+0. 5267	+0. 5269	+ 0. 5	—34. 3	+12. 2026

* B. M.'s XXIV to XXVI were leveled in both directions, the first column containing the forward (*i. e.*, in the direction *from* Carrollton) measures, the second the backward.

† Crossing of the Mississippi River at Baton Rouge by spirit-level and water-level.

SECTION I.—*From Carrollton to Red River Landing, La.*—Continued.

Date, 1880.	Bench-marks.		Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks.			Discrepancy.		Height of bench-mark above average Gulf level (at Biloxi, Miss.).
	From	To			Line with Rod A.	Line with Rod B.	Mean.	Partial "A"—"B."	Total.	
			Km.	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
Mar.										
26	101	102	3.480	219.032	+0.0802	+0.0741	+0.0771	+ 6.1	—28.2	+12.2797
30	102	XXXV	1.978	221.010	—1.9581	—1.9521	—1.9551	— 6.0	—34.2	+10.3246
30	XXXV	109	0.205	221.215	+1.4444	+1.4448	+1.4446	— 0.4	—34.6	+11.7692
29	109	108	2.189	223.404	+0.5952	+0.5938	+0.5945	+ 1.4	—33.2	+12.3637
29	108	107	2.243	225.647	—0.3415	—0.3411	—0.3413	— 0.4	—33.6	+12.0224
29	107	106	1.703	227.350	—0.0301	—0.0341	—0.0321	+ 4.0	—29.6	+11.9903
29	106	105	2.159	229.509	+0.1026	+0.0987	+0.1006	+ 3.9	—25.7	+12.0909
27	105	XXXVI	0.959	230.468	—0.8126	—0.8092	—0.8109	— 3.4	—29.1	+11.2800
27	XXXVI	104	3.037	233.505	+1.1652	+1.1697	+1.1674	— 4.5	—33.6	+12.4474
27	104	103	1.998	235.503	—0.6032	—0.6048	—0.6040	+ 1.6	—32.0	+11.8434
31	103	XXXVII	0.087	235.590	+1.6730	+1.6726	+1.6728	+ 0.4	—31.6	+13.5162
31	XXXVII	111	1.421	237.011	—0.6925	—0.6970	—0.6948	+ 4.5	—27.1	+12.8214
31	111	110	2.306	239.317	—0.3332	—0.3310	—0.3321	— 2.2	—29.3	+12.4893
31	110	XXXVIII	2.755	242.072	—0.6910	—0.6913	—0.6911	+ 0.3	—29.0	+11.7982
Apr.										
5	XXXVIII	XXXIX	1.539	243.611	—0.1325	—0.1339	—0.1332	+ 1.4	—27.6	+11.6650
3	XXXIX	112	3.930	247.541	+1.4660	+1.4677	+1.4669	— 1.7	—29.3	+13.1319
3	112	XL	3.693	251.234	—1.9873	—1.9847	—1.9860	— 2.6	—31.9	+11.1459
9	XL	113	2.215	253.449	+1.9249	+1.9257	+1.9253	— 0.8	—32.7	+13.0712
9	113	XLI	3.799	257.248	—1.0006	—1.0028	—1.0017	+ 2.2	—30.5	+12.0695
10	XLI	114	4.862	262.110	+1.5598	+1.5630	+1.5614	— 3.2	—33.7	+13.6309
15	114	116	1.058	263.168	+0.2493	+0.2493	+0.2493	0.0	—33.7	+13.8802
12	116	XLII	1.437	264.605	+0.2363	+0.2366	+0.2365	— 0.3	—34.0	+14.1167
14	XLII	118	1.681	266.286	—0.1224	—0.1206	—0.1215	— 1.8	—35.8	+13.9952
14	118	117	2.218	268.504	+0.5882	+0.5854	+0.5868	+ 2.8	—33.0	+14.5820
14	117	XLIII	2.774	271.278	—2.9592	—2.9676	—2.9634	+ 8.4	—24.6	+11.6186
16	XLIII	120	2.156	273.434	+2.6281	+2.6197	+2.6239	+ 8.4	—16.2	+14.2425
16	120	121	3.163	276.597	+0.6157	+0.6154	+0.6155	+ 0.3	—15.9	+14.8580
16	121	122	3.717	280.314	—0.1682	—0.1664	—0.1673	— 1.8	—17.7	+14.6907
17	122	123	2.378	282.692	+0.4391	+0.4401	+0.4396	— 1.0	—18.7	+15.1303
17	123	124	2.818	285.510	+0.0162	+0.0168	+0.0165	— 0.6	—19.3	+15.1468
24	124	XLIV	0.829	286.339	—1.5951	—1.5991	—1.5971	+ 4.0	—15.3	+13.5497
24	XLIV	129	2.727	289.066	+1.5556	+1.5561	+1.5559	— 0.5	—15.8	+15.1056
27	129	130	2.796	291.862	—0.5283	—0.5305	—0.5294	+ 2.2	—13.6	+14.5762
26	130	XLV	2.936	294.798	+0.0470	+0.0444	+0.0457	+ 2.6	—11.0	+14.6219
26	XLV	125	0.237	295.035	+0.6685	+0.6675	+0.6680	+ 1.0	—10.0	+15.2899
21	125	126	2.663	297.698	—0.1035	—0.1022	—0.1028	— 1.3	—11.3	+15.1871
23	126	127	1.980	299.678	+0.5310	+0.5290	+0.5300	+ 2.0	— 9.3	+15.7171
23	127	128	2.440	302.118	+0.0502	+0.0516	+0.0509	— 1.4	—10.7	+15.7680

SECTION I.—*Location and description of permanent bench-marks* between Carrollton and Red River Landing, La.*

I.—At Carrollton, Jefferson Parish, La. The center of a cross on the iron sill of the walled-up door near the northwest corner of the Seventh District Babcock Engine House adjoining the New Orleans and Carrollton railroad depot on St. Charles avenue, near Madison street; established by Assistant C. H. Boyd in 1875, and marked thus:†

U. S. C. S.
B. × M.
1875.

Hampson (*Williams*).—A spike driven in wall of blacksmith shop of above-mentioned depot; the shop is on Madison street, and the spike 6 inches below surface of ground and loose (1880).‡

II.—At Twelve Mile Point, 5 miles above Carrollton. A cement post (formed by boring a hole in the ground and filling with cement) in front of Mr. Soniat's house on Carrollton road about 25 paces south of the gate-way.

The bench is the bottom of a slight depression in the surface of the cement and is marked thus:

U. S.
B. □ M.
1880.

III.—At Kennerville, Jefferson Parish, La. The bottom of a square depression in the top of a granite block buried in the yard of Dr. Gustine about 26 metres south of the house, near a date-palm tree. It is marked U. S. B. M.

IV.—On Longue's Plantation, St. Charles Parish, about 4 miles above Kennerville. The head of an iron bolt (about 4 inches long) imbedded in a cement post sunk in the levee, nearly in front of Noibert Longue's house. The post is placed between two large oaks, the second and third from the road on the eastern side of the avenue leading to the river.

V.—On Destréhan Plantation, St. Charles Parish, La. The stone sill of the footway on the western side of the main entrance, the particular spot being indicated by a groove and the letters U. S. B. M. The plantation belongs to Judge Post.

VI.—On Prospect Plantation, St. Charles Parish, La. The upper surface of the square pedestal of the pillar on the eastern side of the front steps of Mr. Sarpy's house. The pedestal is of brick, covered with hard stucco. The bench is the square spot surrounded by a groove and marked U. S. B. M., 1880. The plantation is owned by Leon Sarpy, and is nearly opposite Hahnville.

VII.—On the estate of Mr. Ambruster, St. Charles Parish, La. The head of an iron bolt in a cement post at the foot of a large pecan tree in front of the house. The hole above the bench was filled with fragments of brick and covered with earth. The place is about a half mile below the "Gypsy Plantation," owned by Mr. Labranche, which is at the bend of the river below Bonnet Carré Crevasse.

VIII.—Near Bonnet Carré P. O., St. John Baptist Parish, La. The head of a long iron bolt imbedded in a cement post in the yard of Mr. Adam Lasseigne, just above the post-office.

IX.—On Terre Haute Plantation, St. John Baptist Parish, La. The upper (horizontal) edge of a triangular groove cut in the brick wall of the plantation store, on the west side and at the southwest corner. It is marked U. S. B. M., 1880, No. IX. The plantation is just above the settlement at Bonnet Carré and belongs to Mr. James W. Godberry.

X.—On Mount Airy Plantation, St. John Baptist Parish, La. The upper surface of the granite sill at the foot of the iron stairway in front of the house. The particular spot is surrounded by a groove and marked U. S. B. M., 1880. Plantation extends to the boundary of St. James Parish and belongs to Mr. Joseph Lebourgeois.

XI.—On Belle Alliance Plantation, St. James Parish, La. The upper edge of the groove or

* Where the "bench" is stone post with a square cavity in the top, the *bottom* of the cavity is the point to be taken.

† There is another mark on the sill designated the U. S. E. mark, which is not the one described above.

‡ This is the old Hampson bench; the one re-established by Major Powell of the Mississippi River Commission is about 7 inches above this one. See the Commission's report of 1883, page 129.

triangle cut in the west side of a small brick pier supporting the southwest corner of a wooden warehouse, which stands upon the levee nearly in front of the house. It is designated U. S. B. M., 1880—XI. Plantation belongs to Mr. Wallis.

XII.—On Belmont Plantation, St. James Parish, La. The bottom of a square cavity cut in the corner of the cement pedestal of the column at the southwest corner of the house, and designated U. S. B. M. House and plantation belong to Mr. Louis Lebourgeois.

XIII.—At College Point, just below St. Michaeltown, St. James Parish, La. A horizontal line cut in the iron post on the south side of the Jefferson College front gate-way. Designated XIII—U. S. B. M., 1880, the bench being the line just above the letters B. M.

XIV.—At the "Convent of the Sacred Heart," St. James Parish, La. The bottom of a shallow, square cavity cut in the granite step of the most southern door on the west side of the convent, marked U. S. B. M.

XV.—On Mr. Colomb's house, St. James Parish, La. The upper surface of the stone pedestal of the first pillar on the right-hand side as you ascend the steps to the piazza. The particular spot is surrounded by a groove and designated U. S. B. M.—XV.

XVI.—On Mrs. Hagan's house, 6 miles below Donaldsonville, St. James Parish, La. The surface of a limestone slab on the left-hand side as you ascend the piazza steps. Particular spot marked by a groove and the letters U. S. B. M.

XVII.—Near Mr. Heath's house, about a mile above Donaldsonville, Ascension Parish, La. A granite post buried in the yard, near large pecan tree.

XVIII.—At Mr. V. P. Mirre's house, Ascension Parish, La. A granite post with cement around it buried in the front yard. Place is about 4 miles above Donaldsonville and formerly belonged to Mr. E. Dicharry.

XIX.—On Ashland Plantation, Ascension Parish, La. A cross cut on the head of an iron bolt in the north end of the brick warehouse at Ashland Landing. The bolt is carried entirely through the wall, has a nut screwed on the inner end, is 4.8 feet above the ground, and in the middle of the wall. Designated U. S. B. M., 1880—XIX.

XX.—On Southwood Plantation (formerly called "Hard Times"), situated at the extreme upper end of Ascension Parish, La. A point on the upper surface of the projecting brick foundation running around the house. A square opening was cut through the stucco covering, and the bench is the surface of the brick. Marked U. S. B. M.—1880.

XXI.—On Indian Camp Plantation, Iberville Parish, La. A granite post placed near the house in the angle formed by the central portion of the house and a wing. Plantation belongs to Mrs. Buddington.

XXII.—On Leach, Seaward & Thompson Plantation, about a mile above Bayou Goula, Iberville Parish, La. A granite post sunk in the ground near the oak tree by the house, which is a low, frame building.

XXIII.—At St. Gabriel, Iberville Parish, La. A granite post in the front yard of Julian Grassin, next to St. Gabriel's Church. Plantation formerly belonged to Dr. Pritchard, and is 4 or 5 miles above Bayou Goula.

XXIV.—On Anger's Plantation, Iberville Parish, La. A granite post near the corner of the yard of Mr. Daigre, the overseer. His house is the second one below the "Forlorn Hope" P. O., and just above the bend in the road.

XXV.—On Anger's Plantation, 5 miles above Plaquemine, Iberville Parish, La. A granite post in the northeast corner of the yard of Mr. Walter Humble, on the plantation. The house is a short distance west of the road which runs across the point to "Forlorn Hope" P. O.

XXVI.—On Hollywood Plantation, East Baton Rouge Parish, La. A granite post, 8 metres from the fence at the side of the road and on the line of a row of old fig trees, 23 metres east of the house. Plantation belongs to Mr. H. Vonpuhl, is 12 miles below Baton Rouge, and a half mile above Manchac P. O.

XXVII.—On Cottage Plantation, East Baton Rouge Parish, La. A granite post buried close to the front gate of the inner yard of Mr. Conrad's house. Plantation is on the point 8 miles below Baton Rouge and belongs to Mr. Conrad.

XXVIII.—On Arlington Plantation, East Baton Rouge Parish, La. A granite post placed in the front yard, close to an old brick pier or horse-block near the house. Plantation belongs to Mr. Shannon, and is 4 miles below Baton Rouge.

XXIX.—At South Base, East Baton Rouge Parish, La. A point surrounded by a shallow groove, upon the top of the limestone monument at the south end of the Coast Survey base-line, just below Baton Rouge.

XXX.—At North Base, East Baton Rouge Parish, La. The surface of the limestone monument at the north end of the Baton Rouge Base.

XXXI.—On State House, Baton Rouge, La. A bench-mark of the United States Engineers. The edge of one of the foundation courses of the tower on the north side of the western entrance to the building. It is marked U. S. E.

XXXII.—On Mr. J. H. Gay's plantation, West Baton Rouge Parish, La. A granite post buried in the flower garden in front of the house. Plantation is directly opposite the city of Baton Rouge and just below the ferry landing.

XXXIII.—On Belmont Plantation, West Baton Rouge Parish, La. A granite post buried in front of the pillar at the northwest corner of the house. Plantation belongs to Mr. A. Guesnard.

XXXIV—Near Grossman's Landing, West Baton Rouge Parish, La. A granite post in front of house of Mr. W. B. Chamberlain, jr. House is located about a half mile above Lobdell's store, at Grossman's Landing.

XXXV.—At the "Kelson Store," opposite the upper part of Profit Island, West Baton Rouge Parish, La. A granite post placed in the back corner of the inclosure around the store. Store belongs to Capt. J. J. Brown and land (with exception of store lot) to S. Stirling, of West Feliciana Parish.

XXXVI.—On Sans Souci Plantation, near Hermitage Landing, West Baton Rouge Parish, La. A granite post placed in front of the house of Mr. C. Devall. House fronts on a bayou, the remains of the old river channel, and is on the road leading directly back from the landing.

XXXVII.—At Waterloo, Pointe Coupée Parish, La. The upper edge of a mark cut on the front of the "St. Claude" store, and marked U. S. B. M., 1880. Store is of brick and belongs to a Mr. Robin.

XXXVIII.—At South Base, Pointe Coupée Parish, La. The top of the copper bolt in the limestone monument at the south or lower end of the Coast Survey base-line, which is nearly opposite Bayou Sara Base.

XXXIX.—At North Base, Pointe Coupée Parish, La. The top of copper bolt in limestone monument at north or upper end of above base.

XL.—On Poydras Plantation, Pointe Coupée Parish, La. A granite post placed on the left-hand side as you ascend the front steps of the house. Place belongs to Colonel Claiborne, and is about a half mile above the "new road" leading to the court-house at False River. This part of the parish is known as "Pointe Coupée Settlement."

XLI.—On Morrison Plantation, Pointe Coupée Parish, La. A granite post placed beside the front steps (on the left hand as you ascend) of the house. Plantation belongs to Mr. Morrison's heirs, and is just below the McRae place.

XLII.—At Morganzia, Pointe Coupée Parish, La. A granite post, 3 inches below the surface at the junction of the Grand Levee and a diagonal branch levee running towards the Government light at Morganzia Landing. The spot is about half a mile below the hamlet called Morganzia.

XLIII.—At Raccourci Landing, Pointe Coupée Parish, La. A granite post in front of the house on Mr. Edward Lacour's premises.

XLIV.—On Bella Vista Plantation on Old River, Pointe Coupée Parish, La. A granite post on the left hand as you ascend the front steps of the house. Plantation belongs to Dr. A. A. Batchelor.

XLV.—Near Smithland P. O. at Hog Point Landing, Pointe Coupée Parish, La. A granite post placed in Mr. Archie Smith's yard near the landing.

SECTION II.—*From Red River Landing to Biela's Landing, La., opposite Rodney, Miss.*

[Observer, A. Braid; instrument, geodetic micrometer level No. 1, rods A and B; method of observing, two simultaneous lines run in the same direction (alternate *sections* run in opposite directions)].

Date, 1880–'81.	Bench-marks.		Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks.			Discrepancy.		Height of bench-mark above average Gulf level.
	From	To			Line with		Mean.	Partial "A"–"B."	Total.	
					Rod A.	Rod B.				
1880.			*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
Nov.		127	-----	0.000	--- -----	--------	--------	-----	------	+15.7171
10	127	148	1.067	1.067	— 4.1267	— 4.1230	—4.1249	—3.7	— 3.7	+11.5922
10	148	147	0.123	1.190	— 1.5951	— 1.5954	—1.5952	+0.3	— 3.4	+ 9.9970
10	147	146*	0.454	1.644	— 1.0326†	— 1.0323†	—1.0325	—0.3	— 3.7	+ 8.9645
10	146	145	0.046	1.690	+ 1.2495	+ 1.2489	+1.2492	+0.6	— 3.1	+10.2137
11	145	149	2.118	3.808	+ 3.4282	+ 3.4268	+3.4275	+1.4	— 1.2	+13.6412
11	149	150	2.111	5.919	— 0.0498	— 0.0555	—0.0526	+5.7	+ 4.0	+13.5886
12	150	151	1.289	7.208	+ 0.5487	+ 0.5491	+0.5489	—0.4	+ 3.6	+14.1375
12	151	152	3.075	10.283	+ 1.2946	+ 1.2974	+1.2960	—2.8	+ 0.8	+15.4335
15	152	L	2.074	12.357	+ 0.5559	+ 0.5584	+0.5571	—2.5	— 1.7	+15.9906
15	L	153	0.670	13.027	— 0.3120	— 0.3122	—0.3121	+0.2	— 1.5	+15.6785
15	153	LI	1.424	14.451	+ 0.3510	+ 0.3546	+0.3528	—3.6	— 5.1	+16.0313
15	LI	154	0.735	15.186	+ 1.0167	+ 1.0202	+1.0184	—3.5	— 8.6	+17.0497
16	154	155	1.590	16.776	— 0.8591	— 0.8601	—0.8596	+1.0	— 7.6	+16.1901
19	155	159	1.204	17.980	— 2.0810	— 2.0741	—2.0775	—6.9	—14.5	+14.1126
22	159	160	2.663	20.643	+ 1.1104	+ 1.1115	+1.1109	—1.1	—15.6	+15.2235
22	160	161	2.593	23.236	— 0.4596	— 0.4610	—0.4603	+1.4	—14.2	+14.7632
23	161	LII	3.173	26.409	+ 2.2646	+ 2.2669	+2.2658	—2.3	—16.5	+17.0290
23	LII	162	5.494	31.903	— 1.8420	— 1.8337	—1.8379	—8.3	—24.8	+15.1911
29	162	LIII	0.141	32.044	+ 0.5754	+ 0.5762	+0.5758	—0.8	—25.6	+15.7669
Dec.										
6	LIII	163	5.591	37.635	— 5.2615	— 5.2572	—5.2593	—4.3	—29.9	+10.5076
6	163	164	1.607	39.242	+ 1.7396	+ 1.7404	+1.7400	—0.8	—30.7	+12.2476
7	164	165	2.231	41.473	+ 3.3865	+ 3.3851	+3.3858	+1.4	—29.3	+15.6334
7	165	166	0.746	42.219	— 0.7939	— 0.7930	—0.7935	—0.9	—30.2	+14.8399
7	166	167	3.347	45.566	+ 0.3598	+ 0.3605	+0.3602	—0.7	—30.9	+15.2001
7	167	168	2.912	48.478	+ 1.6533	+ 1.6546	+1.6539	—1.3	—32.2	+16.8540
8	168	LIV	1.017	49.495	+ 0.3489	+ 0.3448	+0.3469	+4.1	—28.1	+17.2009
8	LIV	169	3.436	52.931	— 0.8703	— 0.8714	—0.8704	+1.1	—27.0	+16.3300
8	169	170	3.796	56.727	+ 0.5809	+ 0.5737	+0.5773	+7.2	—19.8	+16.9073
8	170	171	1.200	57.927	— 0.2152	— 0.2202	—0.2177	+5.0	—14.8	+16.6896
10	171	LV	3.030	60.957	+ 0.2669	+ 0.2666	+0.2668	+0.3	—14.5	+16.9564
10	LV	176	0.172	61.129	+ 0.2788	+ 0.2777	+0.2783	+1.1	—13.4	+17.2347
9	176	175	2.469	63.598	— 1.1421	— 1.1457	—1.1439	+3.6	— 9.8	+16.0908
9	175	174	1.581	65.179	— 0.6945	— 0.6902	—0.6924	—4.3	—14.1	+15.3984
9	174	173	0.892	66.071	+ 0.3257	+ 0.3254	+0.3256	+0.3	—13.8	+15.7240
9	173	172	1.450	67.521	+ 0.4113	+ 0.4133	+0.4123	—2.0	—15.8	+16.1363
11	172	LVI	1.386	68.907	+ 2.5721	+ 2.5725	+2.5723	—0.4	—16.2	+18.7086
11	LVI	178½	0.833	69.740	— 0.1423	— 0.1452	—0.1438	+2.9	—13.3	+18.5648

* Crossing of the Red River. † Mean of two determinations.

SECTION II.—*From Red River Landing to Biela's Landing, La., etc.*—**Continued.**

Date, 1880-'81.	Bench-marks.		Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks.			Discrepancy.		Height of bench-mark above average Gulf level.
					Line with					
	From	To			Rod A.	Rod B.	Mean.	Partial "A"-"B."	Total.	
1880.										
Dec.			*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
11	178½	178	1.181	70.921	−0.8995	−0.9020	−0.9007	+2.5	−10.8	+17.6641
11	178	177	3.220	74.141	+0.2248	+0.2290	+0.2269	−4.2	−15.0	+17.8910
14	177	LVII	0.157	74.298	−0.0178	−0.0169	−0.0174	−0.9	−15.9	+17.8736
14	LVII	179	3.163	77.461	−0.8579	−0.8573	−0.8576	−0.6	−16.5	+17.0160
14	179	180	2.411	79.872	+2.0096	+2.0108	+2.0102	−1.2	−17.7	+19.0262
16	180	LVIII	0.844	80.716	−2.6945	−2.6952	−2.6948	+0.7	−17.0	+16.3314
16	LVIII	181	4.049	84.765	+2.9917	+2.9866	+2.9891	+5.1	−11.9	+19.3205
16	181	LIX	1.294	86.059	−0.2398	−0.2443	−0.2420	+4.5	− 7.4	+19.0785
17	LIX	LX	0.772	86.831	+0.3137	+0.3154	+0.3145	−1.7	− 9.1	+19.3930
17	LX	182	3.386	90.217	−0.5413	−0.5431	−0.5422	+1.8	− 7.3	+18.8508
17	182	183	3.436	93.653	+0.6310	+0.6299	+0.6305	+1.1	− 6.2	+19.4813
17	183	184	1.541	95.194	−0.8057	−0.8077	−0.8067	+2.0	− 4.2	+18.6746
18	184	185	2.276	97.470	−0.2043	−0.2001	−0.2022	−4.2	− 8.4	+18.4724
18	185	LXI	2.641	100.111	+0.1106	+0.1124	+0.1115	−1.8	−10.2	+18.5839
18	LXI	186	1.980	102.091	+0.6067	+0.6050	+0.6058	+1.7	− 8.5	+19.1897
27	186	LXII	0.090	102.181	−0.0548	−0.0543	−0.0545	−0.5	− 9.0	+19.1352
27	LXII	LXIII	0.945	103.126	−0.6513	−0.6473	−0.6493	−4.0	−13.0	+18.4859
27	LXIII	189	1.436	104.562	+1.7351	+1.7348	+1.7349	+0.3	−12.7	+20.2208
24	189	LXIV	1.331	105.893	−0.6526	−0.6452	−0.6489	−7.4	−20.1	+19.5719
24	LXIV	188	1.342	107.235	+0.6462	+0.6443	+0.6453	+1.9	−18.2	+20.2172
24	188	187	2.392	109.627	−1.2347	−1.2438	−1.2393	+9.1	− 9.1	+18.9779
31	187	LXV	0.221	109.848	+1.6753	+1.6754	+1.6754	−0.1	− 9.2	+20.6533
31	LXV	190	2.400	112.248	−0.2823	−0.2831	−0.2827	+0.8	− 8.4	+20.3706
31	190	189½	1.710	113.958	+0.2032	+0.2035	+0.2034	−0.3	− 8.7	+20.5740
1881										
Jan.										
7	189½	191	1.912	115.870	−0.3407	−0.3345	−0.3376	−6.2	−14.9	+20.2364
7	191	192	1.820	117.690	−1.6185	−1.6223	−1.6204	+3.8	−11.1	+18.6160
7	192	193	1.025	118.715	+0.0795	+0.0841	+0.0818	−4.6	−15.7	+18.6978
8	193	196	1.878	120.593	+2.6056	+2.6002	+2.6029	+5.4	−10.3	+21.3007
8	196	LXVI	0.119	120.712	−1.8287	−1.8295	−1.8291	+0.8	− 9.5	+19.4716
8	196	195	1.069	121.662	−0.4446	−0.4426	−0.4436	−2.0	−12.3	+20.8571
8	195	194	1.592	123.254	−1.7330	−1.7322	−1.7326	−0.8	−13.1	+19.1245
11	194	197	1.859	125.113	+1.9746	+1.9761	+1.9754	−1.5	−14.6	+21.0999
11	197	198	2.200	127.313	+0.4517	+0.4445	+0.4481	+7.2	− 7.4	+21.5480
11	198	199	2.864	130.177	−1.3309	−1.3360	−1.3335	+5.1	− 2.3	+20.2145
19	199	212	0.783	130.960	−0.0666	−0.0647	−0.0656	−1.9	− 4.2	+20.1489
19	212	LXVII	0.224	131.184	−0.1941	−0.1913	−0.1927	−2.8	− 7.0	+19.9562

SECTION II.—*From Red River Landing to Biela's Landing, La., etc.*—Continued.

Date, 1880–'81.	Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Line with Rod A.	Line with Rod B.	Mean.	Discrepancy. Partial "A"–"B."	Discrepancy. Total.	Height of bench-mark above average Gulf level.
1881.										
Jan.			*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
19	212	211	2.120	133.080	+ 1.3775	+ 1.3792	+ 1.3783	− 1.7	− 5.9	+ 21.5272
19	211	205	1.847	134.927	− 0.4470	− 0.4438	− 0.4454	− 3.2	− 9.1	+ 21.0818
14	205	204	2.183	137.110	+ 0.7174	+ 0.7240	+ 0.7207	− 6.6	−15.7	+ 21.8025
14	204	LXVIII	2.608	139.718	− 0.8383	− 0.8333	− 0.8358	− 5.0	−20.7	+ 20.9667
14	LXVIII	203	1.580	141.298	+ 0.6387	+ 0.6417	+ 0.6402	− 3.0	−23.7	+ 21.6069
13	203	LXIX	0.437	141.735	+ 0.0726	+ 0.0703	+ 0.0715	+ 2.3	−21.4	+ 21.6784
13	LXIX	LXX	1.910	143.645	− 1.1630	− 1.1615	− 1.1623	− 1.5	−22.9	+ 20.5161
13	LXX	202	1.261	144.906	+ 1.6267	+ 1.6279	+ 1.6273	− 1.2	−24.1	+ 22.1434
13	202	201	2.566	147.472	+ 0.3211	+ 0.3166	+ 0.3189	+ 4.5	−19.6	+ 22.4623
13	201	200	1.793	149.265	− 0.7175	− 0.7171	− 0.7173	− 0.4	−20.0	+ 21.7450
15	200	LXXI	0.070	149.335	− 1.4117	− 1.4116	− 1.4117	− 0.1	−20.1	+ 20.3333
15	200	207	1.661	150.926	+ 1.2320	+ 1.2213	+ 1.2266	+10.7	− 9.3	+ 22.9716
15	207	206	2.273	153.199	− 0.2691	− 0.2719	− 0.2705	+ 2.8	− 6.5	+ 22.7011
15	206	LXXII	1.850	155.049	− 0.7618	− 0.7615	− 0.7617	− 0.3	− 6.8	+ 21.9394
17	LXXII	210	2.486	157.535	+ 1.4228	+ 1.4326	+ 1.4277	− 9.8	−16.6	+ 23.3671
17	210	209	1.515	159.050	+ 0.0345	+ 0.0278	+ 0.0311	+ 6.7	− 9.9	+ 23.3982
17	209	208	1.778	160.828	− 0.0397	− 0.0480	− 0.0438	+ 8.3	− 1.6	+ 23.3544
17	208	LXXIII	1.959	162.787	− 1.8720	− 1.8716	− 1.8718	− 0.4	− 2.0	+ 21.4826

[Branch line to bench-marks between Fort Adams, Miss., and Red River Landing, La.]

Date	From	To	Distance between successive bench-marks	Distance from initial mark	Rod A	Rod B	Mean	Partial	Total	Height
1880										
Nov.		155	------	0.000	---------	---------	---------	------	------	+ 16.1901
16	155	156	0.203	0.203	− 3.9108	− 3.9095	− 3.9102	− 1.3	− 1.3	+ 12.2799
19	156	157	0.079	0.282	− 4.6423*	---------	− 4.6423	------	− 1.3	+ 7.6376
19	157	158†	0.790	1.072	+ 0.0260	+ 0.0260	+ 0.0260	0.0	− 1.3	+ 7.6636
17	158	XLIX	1.616	2.688	+13.0020	+13.0024	+13.0022	− 0.4	− 1.7	+ 20.6658
May.										
22	XLIX	137	0.077	2.765	− 1.8367	− 1.8381	− 1.8374	+ 1.4	− 0.3	+ 18.8284
18	137	138	0.888	3.653	+20.7960	+20.7937	+20.7949	+ 2.3	+ 2.0	+ 39.6233
20	138	141	0.972	4.625	+53.2348	+53.2426	+53.2387	− 7.8	− 5.8	+ 92.8620
20	141	142	0.288	4.913	+ 7.9494	+ 7.9488	+ 7.9491	+ 0.6	− 5.2	+100.8111
21	142	143	0.748	5.661	−30.6333	−30.6343	−30.6338	+ 1.0	− 4.2	+ 70.1773
21	143	144	1.252	6.913	−39.2139	−39.2175	−39.2157	+ 3.6	− 0.6	+ 30.9616
22	144	XLVIII	0.238	7.151	− 7.1305	− 7.1304	− 7.1305	− 0.1	− 0.7	+ 23.8311
22	XLVIII	140	1.116	8.267	− 4.6387	− 4.6398	− 4.6393	+ 1.1	+ 0.4	+ 19.1918
19	140	139	0.633	8.900	− 2.8414	− 2.8404	− 2.8409	− 1.0	− 0.6	+ 16.3509

*Mean of two determinations.

†Crossing of the Mississippi River near Fort Adams, Miss.; for description, see C. S. Report, 1880, Appendix 11.

SECTION II.—*From Red River Landing to Biela's Landing, La., etc.*—Continued.

Date, 1880.	Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Line with Rod A.	Line with Rod B.	Mean.	Discrepancy. Partial "A"—"B."	Discrepancy. Total.	Height of bench-mark above average Gulf level.
May.			*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
19	139	136	1.402	10.302	—0.6834	—0.6845	—0.6839	+1.1	+ 0.5	+15.6670
17	136	135	1.481	11.783	+0.1458	+0.1476	+0.1467	—1.8	— 1.3	+15.8137
17	135	134	1.774	13.557	—0.4660	—0.4692	—0.4676	+3.2	+ 1.9	+15.3461
19	134	XLVII	0.196	13.753	—0.4004	—0.4011	—0.4008	+0.7	+ 2.6	+14.9453
19	134	133	2.568	16.125	+0.5110	+0.5044	+0.5077	+6.6	+ 8.5	+15.8538
Apr.										
30	133	132	4.060	20.185	—0.2107	—0.2158	—0.2132	+5.1	+13.6	+15.6406
30	132	XLVI	0.142	20.327	+0.5644	+0.5649	+0.5647	—0.5	+13.1	+16.2053
30	132	131	2.377	22.562	—0.3667	—0.3699	—0.3683	+3.2	+16.8	+15.2723

SECTION II.—*Location and description of permanent bench-marks* between Red River Landing and Biela's Landing, La., opposite Rodney, Miss.*

XLVI.—On Angola Plantation, West Feliciana Parish, La. On the top of the circular wall forming the mouth of a cistern, just back of the house. The bench is the upper surface of the brick exposed by cutting a square aperture through the cement. Marked U. S. B. M. Plantation is nearly opposite the mouth of Red River.

XLVII.—On Tarbert Plantation, Wilkinson County, Miss. A granite post placed close to the back fence of the yard and by a small building. Plantation is owned by Mr. Jenkins, of Natchez, Miss., and lies between Angola and Langside Plantations, extending beyond the State line.

XLVIII.—At Clarksville Landing, Wilkinson County, Miss. A granite post buried at the southeast corner of Lehman & Lauenburgh's store, back of an old cotton-gin, a short distance above the landing.

XLIX.—At Fort Adams, Wilkinson County, Miss. A granite post buried at the southwest corner of Mr. J. R. Mathew's house. The house is just above the "corners" at the upper end of the village.

L.—At Southwest Base, Lum's Point, Concordia Parish, La. The top of the copper bolt in the stone post (10″x 10″ on top), marking the southwest end of Lum's Point Coast Survey base-line. Situated on the place owned by Mr. Lum, of Vicksburg and nearly opposite Fort Adams, Miss.

LI.—At Northeast Base, Lum's Point, Corcordia Parish, La. The top of a copper bolt in the stone post marking the northeast end of above base. Situated on the Point Breeze Plantation, owned by Mr. Trager.

LII.—On Ballamagan Plantation, Concordia Parish, La. A cut in the brick top of the cistern, near the engine-house and about 500 metres south of Mr. E. Pullen's (the lessee) son's residence. This cistern is on the right of the road leading from Point Breeze to Black Hawk, about 3 miles from the latter place. The B. M. is marked U. S. B. M. □ *LII.*

LIII.—At Black Hawk P. O., La. A granite post on the right of the steps leading to the entrance on the east front of Mr. Ed. Pullen's residence. The top is dressed and lettered U. S. B. M.—1880.

* Where the bench is a stone post with a square cavity cut in the top, the *bottom* of the cavity is the point to be taken.

LIV.—On Ashland Plantation, near Bougére P. O., La. A granite post on the left of the steps leading to the front entrance of Mr. W. G. Walton's residence. Marked U. S. B. M.—1880.

LV.—On Brabston Plantation, near Fairview P. O., La. A white marble post on the right of the steps leading to the front entrance of the residence owned by Mr. W. G. Walton. Marked U. S. B. M.—1880.

LVI.—About 3½ miles below B. M. *LVII.* The center of the top of a 6 by 6 inch marble block (a triangulation stone), marked on side facing river U. S. C. & G. S.

LVII.—On Deer Park Plantation, Concordia Parish, La., about 24 miles (by river) below Vidalia. A marble post on the right of the steps leading to the front entrance of the agent's (Mr. James Pipes in 1880) house. This house is about one-fourth mile back from the river bank and just to the southward of the main road leading to Vidalia. The bench is marked U. S. B. M.—1880.

LVIII.—On Ashley Plantation, Concordia Parish, La., about 2 miles below Morville Landing A granite post marking the station "Ashley" in Assistant Boyd's triangulation 1879–'80. It is situated near the river bank close to an old cistern, and is marked U. S. C. & G. S. The center of the top of the post is the bench.*

LIX.—On Moro Plantation, Concordia Parish, La. Center of top of granite post marking the station "Moro" in Assistant Boyd's triangulation. It is situated about a mile above Morville Landing and about half a mile below Mr. A. Crother's (owner of plantation) residence. Marked U. S. C. & G. S.

LX.—On Moro Plantation, Concordia Parish, La. A marble post on the right of the steps leading to the front entrance of Mr. A. Crother's house. Marked U. S. B. M.—1880.

LXI.—About a mile below Vidalia, Concordia Parish, La. The intersection of the cross lines on the top of an iron screw pile used as a triangulation station. It is situated in an open field near the road to Vidalia, on the right-hand side, and marked U. S. C. S. G. P.—1875.†

LXII.—At Vidalia. A marble post on the right of the steps leading to the front entrance of Judge W. H. Hough's residence. Marked U. S. B. M.—1880.

LXIII.—At East Base, near Vidalia Court-House. The center of cross on bolt in granite monument, 14 by 14 inches on top, projecting about 14 inches above the ground, situated in the lot immediately back of the court-house and jail and marking the east end of the Vidalia Base. Lot is owned by Mr. J. Conti, of Natchez, Miss., and stone is marked U. S. C. S.—1878.

LXIV.—At Palo Alto, Concordia Parish, La., about a mile north of Vidalia. The center of cross on top of iron screw pile marking Boyd's triangulation station, Palo Alto. On the property of Mrs. Kate Minor, of Natchez, on the left of the road from Vidalia about 250 metres. Marked U. S. C. S. G. P.—1875.†

LXV.—In levee, about 4½ miles above Vidalia. The bottom of square cavity cut in 5 by 5 inch marble post set in levee near old brick wall. Marked U. S. B. M.—1881.

LXVI.—On Bullits Bayou Plantation, Concordia Parish, La. The bottom of square cavity cut in top of marble post set on right of steps leading to the front entrance of Mr. E. W. Wall's residence at Bullits Bayou Landing, next to the plantation store. Marked U. S. B. M.—1881.

LXVII.—At Gibson's Landing, Concordia Parish, La. The bottom of square cavity cut in marble post set at the northeast corner of Stanton & Brandon's store. Marked U. S. B. M.—1881.

LXVIII.—On Agnasco (Morland estate) Plantation, about half a mile below L'Argent Landing. A cross cut on top of cistern about 51 metres southwest of Mrs. Morland's house. Marked U. S. B. M.

LXIX.—At Duncan, a triangulation point about half a mile above L'Argent, Tensas Parish, La. The head of copper tack in 4 by 4 inch post marking the above triangulation point. Is on S. B. Duncan's plantation, near the end of old levee and about 300 metres from the junction of the old and new levees.

*Assistant Boyd in describing this station states that water was found 3 feet under surface and the post was supported by chips, bricks, etc.

†This is probably the date when the castings were *made* as they were *set* in 1879. G. P. stands for Geodetic Point.

LXX.—About 3 miles below Waterproof, Tensas Parish, La. A cross on top of cistern about 50 metres from the main levee between L'Argent and Waterproof and 190 metres from junction of old and new levees. Marked U. S. B. M.—1881.

LXXI.—At Waterproof. The bottom of square cavity in marble post on the left of steps leading to the front entrance of Mr. A. P. Martin's residence. Marked U. S. B. M.—1881.

LXXII.—At Kemp's Landing, Tensas Parish, La. The bottom of square cavity in marble post on the right of steps leading to the front entrance of Mr. W. H. Goldman's residence. Marked U. S. B. M.—1881.

LXXIII or 297.—On Villa Clara Plantation, Tensas Parish, La., opposite Rodney, Miss. The bottom of square cavity in marble post on the left of steps leading to the front entrance of Capt. E. L. Whitney's residence. Marked U. S. B. M.—1881. Biela's Landing is on Villa Clara Plantation, and Captain Whitney's residence is about one-half mile distant from it and about 6 miles below St. Joseph.

SECTION III.—*From Biela's Landing, La., opposite Rodney, Miss., to Milliken's Bend, La.*

[Observer, J. B. Weir; instrument, geodetic micrometer level No. 3, rods E and F; method of observing, two independent lines run in opposite directions.]

Date, 1880-'81.		Bench-marks.		Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks.			Discrepancy.		Height of bench-mark above average Gulf level.
		From	To			Direction of measure. Forward.*	Backward.†	Mean.	Partial "F"-"B."	Total.	
1881.				*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
Jan.			LXXIII or 297	------	0.000	--------	--------	--------	-----	------	+21.4826
20	20	297	296	1.324	1.324	+0.5864	+0.5815	+0.5840	+4.9	+4.9	+22.0666
18	18	296	295	0.480	1.804	+1.1639	+1.1656	+1.1647	−1.7	+3.2	+23.2313
18	18	295	294	1.396	3.200	−0.5990	−0.5995	−0.5992	+0.5	+3.7	+22.6321
17	17	294	293	0.952	4.152	+1.5223	+1.5224	+1.5223	−0.1	+3.6	+24.1544
17	17	293	292	1.649	5.801	−0.7247	−0.7210	−0.7229	−3.7	−0.1	+23.4315
17	17	292	290	1.456	7.257	−2.2554	−2.2552	−2.2553	−0.2	−0.3	+21.1762
17	17	290	291	0.142	7.399	+1.8499	+1.8496	+1.8498	+0.3	0.0	+23.0260
15	15	290	289	1.373	8.630	+2.0842	+2.0798	+2.0820	+4.4	+4.1	+23.2582
15	15	289	288	1.056	9.686	+0.9825	+0.9803	+0.9814	+2.2	+6.3	+24.2396
14	14	288	287	0.675	10.361	−0.4627	−0.4641	−0.4634	+1.4	+7.7	+23.7762
14	14	287	286	1.358	11.719	+0.9746	+0.9734	+0.9740	+1.2	+8.9	+24.7502
14	14	286	285	0.978	12.697	−2.1004	−2.1001	−2.1002	−0.3	+8.6	+22.6500
13	13	285	284	1.270	13.967	+1.6405	+1.6430	+1.6417	−2.5	+6.1	+24.2917
13	13	284	283	1.293	15.260	+0.1180	+0.1165	+0.1172	+1.5	+7.6	+24.4089
12	12	283	282	0.418	15.678	−0.7560	−0.7571	−0.7566	+1.1	+8.7	+23.6523
12	12	282	281	1.333	17.011	−0.0409	−0.0383	−0.0396	−2.6	+6.1	+23.6127
11	11	281	280	0.807	17.818	+0.0781	+0.0805	+0.0793	−2.4	+3.7	+23.6920
11	11	280	279	1.564	19.382	−0.3505	−0.3523	−0.3514	+1.8	+5.5	+23.3406
8	8	279	278	1.210	20.592	+0.4690	+0.4740	+0.4715	−5.0	+0.5	+23.8121
8	8	278	277	1.234	21.826	+0.0309	+0.0297	+0.0303	+1.2	+1.7	+23.8424
7	7	277	276	2.015	23.841	+0.8973	+0.9027	+0.9000	−5.4	−3.7	+24.7424
7	7	276	275	1.547	25.388	−0.8379	−0.8400	−0.8389	+2.1	−1.6	+23.9035

* *From* Carrollton, La. † *Towards* Carrollton, La.

Section III.—*From Biela's Landing, La., opposite Rodney, Miss., to Milliken's Bend, La.*—Cont'd.

Date, 1880–'81.		Bench-marks.		Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks.			Discrepancy.		Height of bench-mark above average Gulf level.
		From	To			Direction of measure.		Mean.	Partial "F"–"B."	Total.	
						Forward.	Backward.				
1881.											
Jan.				*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
6	6	275	274	2. 121	27. 509	—0. 1168	—0. 1193	—0. 1180	+ 2. 5	+ 0. 9	+23. 7855
4	4	274	273	1. 482	28. 991	—0. 1102	—0. 1117	—0. 1110	+ 1. 5	+ 2. 4	+23. 6745
4	4	273	271	1. 360	30. 351	—1. 3155	—1. 3156	—1. 3156	+ 0. 1	+ 2. 5	+22. 3589
4	4	271	272	0. 139	30. 490	—1. 6002	+1. 5996	+1. 5999	+ 0. 6	+ 3. 1	+23. 9588
3	3	271	270	1. 012	31. 363	+2. 0543	+2. 0588	+2. 0566	— 4. 5	— 2. 0	+24. 4155
1	1	270	269	0. 664	32. 027	+1. 4192	+1. 4158	+1. 4175	+ 3. 4	+ 1. 4	+25. 8330
1	1	269	268	1. 402	33. 429	—1. 5297	—1. 5259	—1. 5278	— 3. 8	— 2. 4	+24. 3052
1880.											
Dec.											
30	30	268	267	1. 916	35. 345	+0. 3845	+0. 3894	+0. 3870	— 4. 9	— 7. 3	+24. 6922
31	31	267	266	0. 768	36. 113	—1. 0413	—1. 0406	—1. 0410	— 0. 7	— 8. 0	+23. 6512
31	31	266	265	0. 490	36. 603	—1. 1495	—1. 1491	—1. 1493	— 0. 4	— 8. 4	+22. 5019
28	28	265	264	0. 901	37. 504	+0. 3129	+0. 3140	+0. 3134	— 1. 1	— 9. 5	+22. 8153
27	27	264	263	0. 986	38. 490	+0. 7299	+0. 7313	+0. 7306	— 1. 4	—10. 9	+23. 5459
27	27	263	261	1. 052	39. 542	+1. 3204	+1. 3214	+1. 3209	— 1. 0	—11. 9	+24. 8668
27	27	261	262	0. 098	39. 640	+0. 3821	+0. 3825	+0. 3823	— 0. 4	—12. 3	+25. 2491
24	24	261	260	1. 546	41. 088	+0. 6323	+0. 6374	+0. 6348	— 5. 1	—17. 0	+25. 5016
23	23	260	259	1. 166	42. 254	—0. 0898	—0. 0868	—0. 0883	— 3. 0	—20. 0	+25. 4133
23	23	259	257	1. 348	43. 602	—0. 7510	—0. 7491	—0. 7501	— 1. 9	—21. 9	+24. 6632
23	23	257	258	0. 098	43. 700	+1. 9424	+1. 9441	+1. 9432	— 1. 7	—23. 6	+26. 6064
22	22	257	256	1. 156	44. 758	—0. 0288	—0. 0298	—0. 0293	+ 1. 0	—20. 9	+24. 6339
Nov.											
22	22	256	255	0. 528	45. 286	—3. 6638	—3. 6646	—3. 6642	+ 0. 8	—20. 1	+20. 9697
22	22	255	254	1. 121	46. 407	+2. 1501	+2. 1507	+2. 1504	— 0. 6	—20. 7	+23. 1201
23	22	254	253	0. 884	47. 291	—1. 2133	—1. 2163	—1. 2148	+ 3. 0	—17. 7	+21. 9053
23	{23 / 25	253	252	0. 699	47. 990	—3. 5497	—3. 5600*	—3. 5549	+10. 3	— 7. 4	+18. 3504
20	20	252	251	0. 622	48. 612	+2. 5440†	2. 5425†	+2. 5432	+ 1. 5	— 5. 9	+20. 8936
23	23	251	250	0. 862	49. 474	+3. 2802	+3. 2798	+3. 2800	+ 0. 4	— 5. 5	+24. 1736
25	25	250	249	0. 934	50. 408	+1. 4518	+1. 4518	+1. 4518	0. 0	— 5. 5	+25. 6254
25	25	249	248	0. 420	50. 828	+0. 0515	+0. 0533	+0. 0524	— 1. 8	— 7. 3	+25. 6778
25	25	248	247	0. 183	51. 011	+0. 7058	+0. 7058	+0. 7058	0. 0	— 7. 3	+26. 3836
Dec.											
21	21	247	245	1. 028	52. 039	+1. 2483	+1. 2494	+1. 2489	— 1. 1	— 8. 4	+27. 6325
21	21	245	246	0. 218	52. 257	—1. 6608	—1. 6616	—1. 6612	+ 0. 8	— 7. 6	+25. 9713
20	20	245	244	0. 912	52. 951	—1. 6412	—1. 6403	—1. 6407	— 0. 9	— 9. 3	+25. 9918
20	20	244	243	1. 164	54. 115	+0. 7627	+0. 7644	+0. 7636	— 1. 7	—11. 0	+26. 7554

* Mean of three determinations. † Mean of two determinations.

SECTION III.—*From Biela's Landing, La., opposite Rodney, Miss., to Milliken's Bend, La.*—Cont'd.

Date, 1880–'81.		Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Direction of measure. Forward.	Difference of height between bench-marks. Direction of measure. Backward.	Difference of height between bench-marks. Mean.	Discrepancy. Partial "F"–"B."	Discrepancy. Total.	Height of bench-mark above average Gulf level.
1880. Dec.				*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
20	20	243	242	0. 214	54. 329	—1. 8677	—1. 8673	—1. 8675	—0. 4	—11. 4	+24. 8879
17	17	242	241	0. 698	55. 027	+0. 9920	+0. 9894	+0. 9907	+2. 6	— 8. 8	+25. 8786
17	17	241	240	1. 062	56. 089	—1. 7897	—1. 7863	—1. 7880	—3. 4	—12. 2	+24. 0906
18	18	240	239	0. 658	56. 747	+2. 2103	+2. 2112	+2. 2108	—0. 9	—13. 1	+26. 3014
18	18	239	238	2. 058	58. 805	+0. 8401	+0. 8379	+0. 8390	+2. 2	—10. 9	+27. 1404
16	16	238	237	0. 762	59. 567	—1. 8260	—1. 8253	—1. 8256	—0. 7	—11. 6	+25. 3148
16	16	237	236	1. 114	60. 681	—0. 4330	—0. 4363	—0. 4346	+3. 3	— 8. 3	+24. 8802
15	15	236	235	1. 047	61. 728	—0. 2961	—0. 2965	—0. 2963	+0. 4	— 7. 9	+24. 5839
15	15	235	234	1. 074	62. 802	—0. 1371	—0. 1363	—0. 1367	—0. 8	— 8. 7	+24. 4472
14	14	234	233	0. 476	63. 278	+1. 6325	+1. 6318	+1. 6322	+0. 7	— 8. 0	+26. 0794
14	14	233	231	1. 394	64. 672	+2. 0093	+2. 0127	+2. 0110	—3. 4	—11. 4	+28. 0904
13	13	231	232	0. 333	65. 005	—1. 5330	—1. 5314	—1. 5322	—1. 6	—13. 0	+26. 5582
13 / 14	14	231	230	0. 906	65. 578	—0. 3706*	—0. 3736	—0. 3721	+3. 0	— 8. 4	+27. 7183
11	11	230	229	1. 300	66. 878	+0. 0587	+0. 0578	+0. 0582	+0. 9	— 7. 5	+27. 7765
11	11	229	228	1. 356	68. 234	+0. 9918	+0. 9910	+0. 9914	+0. 8	— 6. 7	+28. 7679
10	10	228	227	1. 235	69. 469	—0. 6514	—0. 6509	—0. 6511	—0. 5	— 7. 2	+28. 1168
10	10	227	226	1. 324	70. 793	—1. 0498	—1. 0545	—1. 0522	+4. 7	— 2. 5	+27. 0646
9	10	226	225	0. 454	71. 247	+0. 4943	+0. 4943	+0. 4943	0. 0	— 2. 5	+27. 5589
9	10	225	224	0. 874	72. 121	—1. 6238	—1. 6273	—1. 6255	+3. 5	+ 1. 0	+25. 9334
9	9	224	223	0. 729	72. 850	+0. 6296	+0. 6297	+0. 6296	—0. 1	+ 0. 9	+26. 5630
8	8	223	222	0. 798	73. 648	—0. 5973	—0. 5970	—0. 5972	—0. 3	+ 0. 6	+25. 9658
8	8	222	221	1. 184	74. 832	+0. 7779	+0. 7760	+0. 7770	+1. 9	+ 2. 5	+26. 7428
7	7	221	220	1. 014	75. 846	—0. 5246	—0. 5209	—0. 5228	—3. 7	— 1. 2	+26. 2200
7	7	220	219	1. 134	76. 980	+0. 1576	+0. 1597	+0. 1586	—2. 1	— 3. 3	+26. 3786
6	6	219	218	0. 818	77. 798	—0. 4896	—0. 4846	—0. 4871	—5. 0	— 8. 3	+25. 8915
6	6	218	217	1. 258	79. 056	+0. 2669	+0. 2688	+0. 2678	—1. 9	—10. 2	+26. 1593
4	4	217	216	0. 794	79. 850	—0. 0977	—0. 0985	—0. 0981	+0. 8	— 9. 4	+26. 0612
4 / 6	4 / 6	216	214	0. 792	80. 642	+0. 0472*	+0. 0516*	+0. 0494	—4. 4	—13. 8	+26. 1106
4	4	214	215	0. 102	80. 744	+1. 6120	+1. 6115	+1. 6117	+0. 5	—13. 3	+27. 7223
4	4	214	213	0. 762	81. 404	—0. 7089	—0. 7102	—0. 7095	+1. 3	—12. 5	+25. 4011
2	2	213	212	0. 746	82. 150	+2. 6102	+2. 6105	+2. 6104	—0. 3	—12. 8	+28. 0115
Nov. 17	Dec. 1	212	210	1. 944	84. 094	+0. 3773	+0. 3788	+0. 3781	—1. 5	—14. 3	+28. 3896
Dec. 1	1	210	211	0. 093	84. 187	—0. 7811	—0. 7811	—0. 7811	0. 0	—14. 3	+27. 6085
1	1	210	209	1. 047	85. 141	—0. 5331	—0. 5340	—0. 533	+0. 9	—13. 4	+27. 8561

* Mean of two determinations.

SECTION III.—*From Biela's Landing, La., opposite Rodney, Miss., etc.*—Continued.

Date, 1880–'81.		Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Direction of measure. Forward.	Backward.	Mean.	Discrepancy. Partial "F"–"B."	Total.	Height of bench-mark above average Gulf level.
1880. Nov.				*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
16	16	209	208	1.338	86.529	—0.7317	—0.7325	—0.7321	+0.8	—12.6	+27.1240
16	16	208	206	0.790	87.319	+1.1538	+1.1521	+1.1529	+1.7	—10.9	+28.2769
15	15	206	207	0.254	87.573	+1.3443	+1.3420	+1.3431	+2.3	— 8.6	+29.6200
15	15	206	205	0.764	88.083	—0.0744	—0.0784	—0.0764	+4.0	— 6.9	+28.2005
15	15	205	204	0.789	88.872	+0.0209	+0.0213	+0.0211	—0.4	— 7.3	+28.2216
13	13	204	203	1.682	90.554	+1.1933	+1.1916	+1.1925	+1.7	— 5.6	+29.4141
12	12	203	202	0.767	91.321	—0.0706	—0.0725	—0.0716	+1.9	— 3.7	+29.3425
12	12	202	201	0.837	92.158	+0.7006	+0.6993	+0.7000	+1.3	— 2.4	+30.0425
11	11	201	200	0.387	92.545	+0.0353	+0.0346	+0.0350	+0.7	— 1.7	+30.0775
11	11	200	199	0.768	93.313	—0.7739	—0.7732	—0.7735	—0.7	— 2.4	+29.3040
10, 12	11, 12	199	198	0.837	94.150	+0.2672*	+0.2669*	+0.2671	+0.3	— 2.1	+29.5711
10	10	198	196	0.958	95.108	—0.4112	—0.4123	—0.4117	+1.1	— 1.0	+29.1594
10	10	196	197	0.107	95.215	+0.3158	+0.3158	+0.3158	0.0	— 1.0	+29.4752
9	9	196	195	1.017	96.125	—0.3609	—0.3577	—0.3593	—3.2	— 4.2	+28.8001
9	9	195	194	0.960	97.085	—0.5168	—0.5119	—0.5144	—4.9	— 9.1	+28.2857
9	9	194	193	0.817	97.902	+1.1295	+1.1232	+1.1263	+6.3	— 2.8	+29.4120
5	6	193	192	0.410	98.312	+0.6117	+0.6095	+0.6106	+2.2	— 0.6	+30.0226
6	6	192	191	0.809	99.121	—0.0876	—0.0858	—0.0867	—1.8	— 2.4	+29.9359
6	6	191	190	0.632	99.753	+0.0850	+0.0817	+0.0834	+3.3	+ 0.9	+30.0193
8	8	190	189	1.002	100.755	—0.1942	—0.1900	—0.1921	—4.2	— 3.3	+29.8272
8	8	189	188	0.756	101.511	+0.0839	+0.0828	+0.0834	+1.1	— 2.2	+29.9106

* Mean of two determinations.

SECTION III.—*Location and description of permanent bench-marks between Biela's Landing, La., opposite Rodney, Miss., and Milliken's Bend, La.*

LXXIII or 297.—Described in Section II.

291.—On Duck Pond Plantation, Tensas Parish, La. The center of head of copper bolt leaded horizontally in north face of brick chimney of gin-house. Is in the seventh course below the projecting course and fifth brick from northeast edge of chimney.

286.—On Panola Plantation, Tensas Parish, La. The center of head of copper bolt in brick chimney of gin-house. Is in the twenty-third course from ground and fourth brick from northeast corner.

280.—On Waveland Plantation, Tensas Parish, La. The center of head of copper bolt in southeast face of brick chimney of gin-house. Is in the middle brick of tenth course from foundation.

272.—On Hard Times Plantation, Tensas Parish, La. The top of copper bolt imbedded vertically in a block of cement 8 inches in diameter, set about 50 metres south of the bank of Lake St. Joseph, near a cabin.

262.—On Riverside Plantation, Tensas Parish, La. The center of head of copper bolt in middle brick of twelfth course from foundation, in south face of east chimney of dwelling on plantation.

258.—On Point Pleasant Plantation, Tensas Parish, La. The center of head of copper bolt in brick 4 feet from the ground and in middle of north face of north chimney of dwelling.

246.—On Sargent's Point Plantation, Madison Parish, La. The top of copper bolt imbedded in a block of cement 8 inches in diameter, set near cabins surrounded by water oaks and pecans, about 600 metres from channel of river.

243.—At Kellogg's Landing, Madison Parish, La. The center of head of copper bolt in brick 15 inches from ground and in middle of south face of southeast chimney of Kellogg's post-office building.

232.—On Crystal Springs Plantation, Madison Parish, La. The center of head of copper bolt in brick of twelfth course from ground and second one from southeast edge of east chimney of dwelling.

225.—On Point Place Plantation, Madison Parish, La. The center of head of copper bolt in middle brick of tenth course from the ground of second pillar from southeast corner of dwelling-house. Plantation is opposite Warrenton, Miss.

215.—In Delta, Madison Parish, La., opposite Vicksburg, Miss. The end of vertical ray of five-rayed cast-iron star, used as a tie-plate, in south end of parish clerk's office near court-house. Is about 4 feet from ground and 3 from southeast corner of building.

211.—On Willow Glenn Plantation, Madison Parish, La. The center of head of copper bolt in middle brick of eighth course from ground of second pillar from southeast corner of dwelling-house porch.

207.—On Elcho Plantation, Madison Parish, La. The center of head of copper bolt in brick in twenty-first course from ground, and third one from southeast edge of south chimney of dwelling-house.

197.—On Duck Port Plantation, Madison Parish, La. The center of head of copper bolt in middle brick of third course from top of third pillar from northeast corner of dwelling-house porch.

188.—On Cabin Teele Plantation, Madison Parish, La. The center of head of copper bolt in brick in east face of brick pillar supporting the northeast corner of dwelling-house.

SECTION IV.—*From Milliken's Bend, La., to Greenville, Miss.*

[Observers, O. H. Tittman and J. B. Weir; instruments, geodetic micrometer levels 3 and 36, rods C, D, E, and F; method of observing, two independent lines run in opposite directions as far as B. M. 25, from whence to close of line, two simultaneous lines supplemented by a single line in the opposite direction.]

Date, 1880.		Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Direction of measure. Forward.	Backward.	Mean.	Discrepancy. Partial "F"-"B."	Total.	Height of bench-mark above average Gulf level.
May.				*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
			188	-----	0.000	--------	--------	--------	-----	0.0	+29.9106
17	17	188	187	0.473	0.473	—0.0895	—0.0880	—0.0888	—1.5	— 1.5	+29.8218
17	17	187	186	0.780	1.253	+0.2471	+0.2466	+0.2468	+0.5	— 1.0	+30.0686
17	17	186	185	1.073	2.326	+0.7637	+0.7621	+0.7629	+1.6	+ 0.6	+30.8315
17	17	185	183	0.854	3.180	—1.1012	—1.0981	—1.0997	—3.1	— 2.5	+29.7318
18	18	183	184	0.802	3.982	—1.1167	—1.1173	—1.1170	+0.6	— 1.9	+28.6148

SECTION IV.—*From Milliken's Bend, La., to Greenville, Miss.*—Continued.

Date, 1880.		Bench-marks.		Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks.			Discrepancy.		Height of bench-mark above average Gulf level.
		From	To			Direction of measure.		Mean.	Partial "F"–"B."	Total.	
						Forward.	Backward.				
May.				*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
14	14	183	182	0.846	4.026	−0.2817	−0.2809	0.2813	−0.8	− 3.3	+29.4505
14	14	182	181	0.806	4.832	+0.3829	+0.3818	+0.3823	+1.1	− 2.2	+29.8328
14	14	181	180	0.796	5.628	−0.6497	−0.6477	−0.6487	−2.0	− 4.2	+29.1841
14 15	14 15	180	178	1.003	6.631	−0.0252*	−0.0295*	−0.0273	+4.3	+ 0.1	+29.1568
13	13	178	179	0.686	7.317	+0.4067	+0.4077	+0.4072	−1.0	− 0.9	+29.5640
13	13	178	177	0.562	7.193	+0.3241	+0.3240	+0.3240	+0.1	+ 0.2	+29.4808
13	13	177	176	0.928	8.121	−1.0307	−1.0359	−1.0333	+5.2	+ 5.4	+28.4475
12 15	12 15	176	175	0.804	8.925	+0.5615*	+0.5603*	+0.5609	+1.2	+ 6.6	+29.0084
12 15	12 15	175	174	0.790	9.715	+0.3066*	+0.3072*	+0.3069	−0.6	+ 6.0	+29.3153
12	12	174	173	0.769	10.484	+0.4509	+0.4459	+0.4484	+5.0	+11.0	+29.7637
11	11	173	172	1.470	11.954	−0.1659	−0.1636	−0.1648	−2.3	+ 8.7	+29.5989
11 12	11 12	172	171	0.905	12.859	−0.3313*	−0.3325*	−0.3319	+1.2	+ 9.9	+29.2670
11	11	171	170	0.204	13.063	+0.3051	+0.3036	+0.3043	+1.5	+11.4	+29.5713
11	10	170	169	0.659	13.722	+0.4239	+0.4230	+0.4234	+0.9	+12.3	+29.9947
10	10	169	168	1.340	15.062	−0.2454	−0.2451	−0.2452	−0.3	+12.0	+29.7495
10	10	168	167	1.260	16.322	+0.5204	+0.5158	+0.5181	+4.6	+16.6	+30.2676
10	10	167	166	0.732	17.054	0.4850	−0.4830	−0.4840	−2.0	+14.6	+29.7836
8	8	166	165	0.810	17.864	+0.1755	+0.1765	+0.1760	−1.0	+13.6	+29.9596
8	8	165	164	1.329	19.193	+0.4352	+0.4375	+0.4364	−2.3	+11.3	+30.3960
8	8	164	163	0.814	20.007	−0.1792	−0.1764	−0.1778	−2.8	+ 8.5	+30.2182
7	7	163	162	1.057	21.064	+0.6519	+0.6502	+0.6511	+1.7	+10.2	+30.8693
7	7	162	161	0.924	21.988	−0.8085	−0.8080	−0.8083	−0.5	+ 9.7	+30.0610
7 8	7 8	161	160	0.666	22.654	−0.2905*	−0.2937*	−0.2921	3.2	+12.9	+29.7689
5	5	160	159	0.414	23.068	−0.0561	−0.0563	−0.0562	+0.2	+13.1	+29.7127
5	5	159	158	0.782	23.850	−0.0282	−0.0312	−0.0297	+3.0	+16.1	+29.6830
5	5	158	157	0.868	24.718	+0.1888	+0.1857	+0.1872	+3.1	+19.2	+29.8702
3	3	157	156	0.384	25.102	−0.1015	−0.1011	−0.1013	−0.4	+18.8	+29.7689
1 3	--	156	155†	2.311	27.413	+0.3819	--------	+0.3819	-------	------	+30.1508
3	1	155	154	0.958	28.371	+1.0817	+1.0823	+1.0820	0.6	− 0.6‡	+31.2328
3	1	154	152	0.355	28.726	−0.6802	−0.6780	−0.6791	−2.2	− 2.8	+30.5537
Apr.											
30	30	152	153	0.960	29.686	+1.1025	+1.1048	+1.1037	−2.3	− 5.1	+31.6574
30	29	152	151	1.452	30.178	−0.0660	−0.0709	−0.0684	+4.9	+ 2.1	+30.4853
28	29	151	150	0.513	30.691	+1.5061	+1.5053	+1.5057	+0.8	+ 2.9	+31.9910

* Mean of two determinations. † Mississippi River Crossing; mean of 21 determinations.

‡ A fresh start made with B. M. 155, adopting 0.0 for it.

SECTION IV.—*From Milliken's Bend, La., to Greenville, Miss.*—Continued.

Date, 1880.		Bench-marks.		Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks.			Discrepancy.		Height of bench-mark above average Gulf level.
		From	To			Direction of measure.		Mean.	Partial "F"—"B."	Total.	
						Forward.	Backward.				
Apr.				*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
28	29	150	149	1.190	31.881	—0.8995	—0.8987	—0.8991	—0.8	+ 2.1	+31.0919
28	28	149	148	1.042	32.923	+0.6149	+0.6145	+0.6147	+0.4	+ 2.5	+31.7066
27	27	148	147	0.819	33.742	—0.6734	—0.6750	—0.6742	+1.6	+ 4.1	+31.0324
27	27	147	146	0.776	34.518	+0.2316	+0.2317	+0.2316	—0.1	+ 4.0	+31.2640
27	27	146	145	0.778	35.296	—0.1023	—0.1004	—0.1014	—1.9	+ 2.1	+31.1626
27	27	145	144	0.824	36.120	—0.1104	—0.1102	—0.1103	—0.2	+ 1.9	+31.0523
26	26	144	143	0.947	37.067	+0.2046	+0.2014	+0.2030	+3.2	+ 5.1	+31.2553
26	26	143	142	0.908	37.975	+0.1069	+0.1097	+0.1083	—2.8	+ 2.3	+31.3636
26	26	142	141	0.843	38.818	+0.6802	+0.6805	+0.6803	—0.3	+ 2.0	+32.0439
26	26	141	140	0.943	39.761	+1.5959	+1.5984	+1.5971	—2.5	— 0.5	+33.6410
22	22	140	139	0.967	40.728	—1.9408	—1.9356	—1.9382	—5.2	— 5.7	+31.7028
22	22	139	138	0.886	41.614	+0.8089	+0.8068	+0.8079	+2.1	— 3.6	+32.5107
22	22	138	137	0.603	42.217	—0.3943	—0.3952	—0.3948	+0.9	— 2.7	+32.1159
22	22	137	136	0.785	43.002	—0.8798	—0.8812	—0.8805	+1.4	— 1.3	+31.2354
21	21	136	135	1.178	44.180	+1.5768	+1.5749	+1.5758	+1.9	+ 0.6	+32.8112
21	21	135	134	0.852	45.032	—0.4521	—0.4522	—0.4521	+0.1	+ 0.7	+32.3591
21	21	134	133	1.239	46.271	—0.4911	—0.4888	—0.4899	—2.3	— 1.6	+31.8692
20	20	133	132	1.309	47.580	+0.0378	+0.0417	+0.0398	—3.9	— 5.5	+31.9090
20	20	132	131	0.936	48.516	+0.7816	+0.7803	+0.7809	+1.3	— 4.2	+32.6899
20	20	131	130	0.808	49.324	—0.0868	—0.0862	—0.0865	—0.6	— 4.8	—32.6034
19	19	130	129	0.618	49.942	—0.0992	—0.0988	—0.0990	—0.4	— 5.2	+32.5044
19	19	129	127	1.070	51.012	—0.4037	—0.4003	—0.4020	—3.4	— 8.6	+32.1024
19	19	127	128	0.596	51.608	+0.1262	+0.1245	+0.1254	+1.7	— 6.9	+32.2278
16	16	127	126	0.828	51.840	+0.2656	+0.2669	+0.2662	—1.3	— 9.9	+32.3686
16	16	126	125	0.896	52.736	—0.1470	—0.1469	—0.1470	—0.1	—10.0	+32.2216
17	17	125	123	0.862	53.598	+1.4741	+1.4719	+1.4730	+2.2	— 7.8	+33.6946
17	17	123	124	0.315	53.913	—2.0626	—2.0628	—2.0627	+0.2	— 7.6	+31.6319
17	17	123	122	0.866	54.464	—0.2189	—0.2161	—0.2175	—2.8	—10.6	+33.4771
17	17	122	121	1.205	55.669	—0.3431	—0.3416	—0.3424	—1.5	—12.1	+33.1347
15	15	121	120	0.924	56.593	—0.2541	—0.2528	—0.2535	—1.3	—13.4	+32.8812
15	15	120	119	0.699	57.292	+0.3019	+0.3010	+0.3015	+0.9	—12.5	+33.1827
15	15	119	118	0.867	58.159	—0.3846	—0.3811	—0.3829	—3.5	—16.0	+32.7998
14 15	14 15	118	117	1.282	59.441	+0.5321*	+0.5375*	+0.5348	—5.4	—21.4	+33.3346
14	14	117	116	0.975	60.416	—1.2284	—1.2290	—1.2287	+0.6	—20.8	+32.1059
13	13	116	115	0.716	61.132	—0.2637	—0.2667	—0.2652	+3.0	—17.8	+31.8407
13	13	115	114	0.738	61.870	+1.1083	+1.1087	+1.1085	—0.4	—18.2	+32.9492
13	13	114	113	0.854	62.724	—0.6533	—0.6558	—0.6546	+2.5	—15.7	+32.2946
13	13	113	111	0.838	63.562	+0.2165	+0.2205	+0.2185	—4.0	—19.7	+32.5131
12	12	111	112	0.669	64.231	+0.5740	+0.5789	+0.5764	—4.9	—24.6	+33.0895

* Mean of two determinations.

SECTION IV.—*From Milliken's Bend, La., to Greenville, Miss.*—Continued.

Date, 1880.		Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Direction of measure. Forward.	Backward.	Mean.	Discrepancy. Partial "F"–"B."	Total.	Height of bench-mark above average Gulf level.
Apr.				*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
12	12	111	110	0.808	64.370	−0.5664	−0.5661	−0.5662	−0.3	−20.0	+31.9469
12	12	110	109	0.991	65.361	+0.8776	+0.8796	+0.8786	−2.0	−22.0	+32.8255
12 14	12 14	109	108	0.790	66.151	−0.4189*	−0.4156*	−0.4172	−3.3	−25.3	+32.4083
8	8	108	107	0.948	67.099	+1.1676	+1.1694	+1.1685	−1.8	−27.1	+33.5768
8	8	107	106	1.036	68.135	−0.5228	−0.5212	−0.5220	−1.6	−28.7	+33.0548
9	10	106	104	0.997	69.132	+0.4725	+0.4683	+0.4704	+4.2	−24.5	+33.5252
10	10	104	105	0.592	69.724	−0.6460	−0.6483	−0.6472	+2.3	−22.2	+32.8780
9 10	9 10	104	103	0.979	70.111	−0.2317*	−0.2260*	−0.2289	−5.7	−30.2	+33.2963
9	9	103	102	0.982	71.093	+0.4489	+0.4539	+0.4514	−5.0	−35.2	+33.7477
9	9	102	101	1.274	72.367	+0.3084	+0.3042	+0.3063	+4.2	−31.0	+34.0540
6	6	101	100	0.382	72.749	−0.0438	−0.0385	−0.0412	−5.3	−36.3	+34.0128
6	6	100	99	0.673	73.422	−0.0217	−0.0215	−0.0216	−0.2	−36.5	+33.9912
6	5	99	98	1.456	74.878	−1.6328	−1.6354	−1.6341	+2.6	−33.9	+32.3571
5 6	5 6	98	97	0.949	75.827	+1.6460*	+1.6491*	+1.6475	−3.1	−37.0	+34.0046
3	3	97	96	1.182	77.009	+0.2846	+0.2859	+0.2852	−1.3	−38.3	+34.2898
5	3	96	95	0.830	77.839	−0.3502	−0.3511	−0.3506	+0.9	−37.4	+33.9392
2 3	2 3	95	94	0.507	78.346	−0.4368*	−0.4412*	−0.4390	+4.4	−33.0	+33.5002
1	1	94	93	1.114	79.460	−0.7670	−0.7691	−0.7681	+2.1	−30.9	+32.7321
1	1	93	92	0.799	80.259	−0.5599	−0.5579	−0.5589	−2.0	−32.9	+32.1732
1 2	1 2	92	91	0.894	81.153	+1.5873*	+1.5834*	+1.5854	+3.9	−29.0	+33.7586
Mar.											
30	30	91	90	0.982	82.135	−0.1046	−0.1034	−0.1040	−1.2	−30.2	+33.6546
30 31	30 31	90	89	1.322	83.457	+0.3232*	+0.3304*	+0.3268	−7.2	−37.4	+33.9814
30 31	30 31	89	88	1.201	84.658	−0.5523*	−0.5487*	−0.5505	−3.6	−41.0	+33.4309
29	29	88	87	1.304	85.962	+0.8853	+0.8888	+0.8871	−3.5	−44.5	+34.3180
29	29	87	86	0.745	86.707	+0.1509	+0.1489	+0.1499	+2.0	−42.5	+34.4679
29	29	86	85	0.983	87.690	−2.3696	−2.3733	−2.3715	+3.7	−38.8	+32.0964
27	27	85	84	0.336	88.026	+2.1175	+2.1184	+2.1179	−0.9	−39.7	+34.2143
27	27	84	83	0.932	88.958	+0.0986	+0.1032	+0.1009	−4.6	−44.3	+34.3152
27	27	83	82	0.381	89.339	−0.5611	−0.5612	−0.5611	+0.1	−44.2	+33.7541
26	26	82	81	1.080	90.419	−1.0065	−1.0047	−1.0056	−1.8	−46.0	+32.7485
26	26	81	80	0.630	91.049	+0.5576	+0.5601	+0.5589	−2.5	−48.5	+33.3074
25	25	80	79	1.006	92.055	+0.2415	+0.2450	+0.2433	−3.5	−52.0	+33.5507
25	25	79	78	0.871	92.926	+0.0525	+0.0574	+0.0549	−4.9	−56.9	+33.6056
24	24	78	77	0.821	93.747	+0.4932	+0.4925	+0.4929	+0.7	−56.2	+34.0985

* Mean of two determinations.

SECTION IV.—*From Milliken's Bend, La., to Greenville, Miss.*—Continued.

Date, 1880.		Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Direction of measure. Forward.	Backward.	Mean.	Discrepancy. Partial "F"—"B."	Total.	Height of bench-mark above average Gulf level.
Mar.				*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
24	24	77	76	0.904	94.651	+0.0801	+0.0815	+0.0808	−1.4	−57.6	+34.1793
24	24	76	75	0.479	95.130	−0.1270	−0.1305	−0.1288	+3.5	−54.1	+34.0505
24	24	75	74	1.022	96.152	+1.3657	+1.3637	+1.3647	+2.0	−52.1	+35.4152
23	23	74	73	0.777	96.929	+0.9785	+0.9793	+0.9789	−0.8	−52.9	+36.3941
23	23	73	72	1.004	97.933	−0.9064	−0.9068	−0.9066	+0.4	−52.5	+35.4875
22	22	72	71	0.976	98.909	−0.4548	−0.4572	−0.4560	+2.4	−50.1	+35.0315
22	22	71	70	0.594	99.503	−0.4614	−0.4620	−0.4617	+0.6	−49.5	+34.5698
20	20	70	69	0.838	100.341	−0.4645	−0.4679	−0.4662	+3.4	−46.1	+34.1036
20	20	69	68	0.588	100.929	+0.1203	+0.1217	+0.1210	−1.4	−47.5	+34.2246
19	19	68	67	1.280	102.209	+0.0254	+0.0289	+0.0272	−3.5	−51.0	+34.2518
19 20 22	19 20 22	67	66	0.562	102.771	+1.8232†	+1.8308†	+1.8270	−7.6	−58.6	+36.0788
18	19	66	65	1.080	103.851	+0.4708	+0.4705	+0.4706	+0.3	−58.3	+36.5494
18	18	65	64	1.317	105.168	−0.9205	−0.9195	−0.9200	−1.0	−59.3	+35.6294
17	17	64	63	1.099	106.267	+0.0167	+0.0199	+0.0183	−3.2	−62.5	+35.6477
17	17	63	62	0.804	107.071	+0.7449	+0.7454	+0.7451	−0.5	−63.0	+36.3928
16	16	62	61	0.348	107.419	−0.0419	−0.0425	−0.0422	+0.6	−62.4	+36.3506
16	16	61	60	1.042	108.461	−0.5844	−0.5880	−0.5862	+3.6	−58.8	+35.7644
16	16	60	59	1.046	109.507	+0.2162	+0.2159	+0.2160	+0.3	−58.5	+35.9804
13	13	59	58	1.294	110.801	+0.3151	+0.3146	+0.3148	+0.5	−58.0	+36.2952
13	13	58	57	1.189	111.990	+0.3033	+0.3049	+0.3041	−1.6	−59.6	+36.5993
13	12	57	56	1.096	113.086	−0.8647	−0.8622	−0.8635	−2.5	−62.1	+35.7358
13	12	56	55	0.422	113.508	+1.6913	+1.6916	+1.6914	−0.3	−62.4	+37.4272
12	12	55	54	1.406	114.914	+0.8649	+0.8660	+0.8655	−1.1	−63.5	+38.2927
11	11	54	53	0.988	115.902	−0.5541	−0.5544	−0.5542	+0.3	−63.2	+37.7385
11	11	53	52	0.776	116.678	−0.3832	−0.3821	−0.3827	−1.1	−64.3	+37.3558
10	10	52	51	0.721	117.399	−0.2991	−0.3038	−0.3014	+4.7	−59.6	+37.0544
10	10	51	50	1.100	118.499	−2.3733	−2.3696	−2.3714	−3.7	−63.3	+34.6830
11	10	50	49	1.061	119.560	−0.1292	−0.1259	−0.1276	−3.3	−66.6	+34.5554
9	9	49	48	0.856	120.416	+0.7283	+0.7284	+0.7284	−0.1	−66.7	+35.2838
9	9	48	47	0.932	121.348	+1.4301	+1.4301	+1.4301	0.0	−66.7	+36.7139
Feb. 26 Mar. 6	Feb. 26 Mar. 6	47	46	1.116	122.464	−0.3753*	−0.3747*	−0.3750	−0.6	−67.3	+36.3389
Feb. 26 Mar. 4, 7	Feb. 26 Mar. 4	46	44	1.606	124.070	+0.4740†	+0.4693†	+0.4716	+4.7	−62.6	+36.8105
Feb.											
25	24	44	43	1.060	125.130	−0.6059	−0.6100	−0.6079	+4.1	−58.5	+36.2026
23	21	43	42	1.052	126.182	+0.2389	+0.2382	+0.2385	+0.7	−57.8	+36.4411
21	21	42	41	0.569	126.751	−1.4572	−1.4573	−1.4572	+0.1	−57.7	+34.9839
21	21	41	40	1.294	128.045	+0.0058	+0.0016	+0.0037	+4.2	−53.5	+34.9876
21	20	40	39	1.049	129.094	+0.9739	+0.9707	+0.9723	+3.2	−50.3	+35.9599

†Mean of three determinations. * Mean of two determinations.

SECTION IV.—*From Milliken's Bend, La., to Greenville, Miss.*—Continued.

Date, 1880.		Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Direction of measure. Forward.	Backward.	Mean.	Discrepancy. Partial "F"-"B."	Total.	Height of bench-mark above average Gulf level.
Feb.				*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
20	20	39	38	1. 440	130. 534	+1. 3709	+1. 3656	+1. 3683	+ 5. 3	−45. 0	+37. 3282
20	20	38	37	1. 139	131. 673	−1. 0338	−1. 0346	−1. 0342	+ 0. 8	−44. 2	+36. 2940
19	19	37	36	1. 294	132. 967	+1. 1956	+1. 1905	+1. 1930	+ 5. 1	−39. 1	+37. 4870
19	19	36	35	1. 223	134. 190	−0. 9888	−0. 9821	−0. 9855	− 6. 7	−45. 8	+36. 5015
18	19	35	34	1. 128	135. 318	+0. 0865	+0. 0829	+0. 0847	+ 3. 6	−42. 2	+36. 5862
17	17	34	33	1. 410	136. 728	+0. 2416	+0. 2324	+0. 2370	+ 9. 2	−33. 0	+36. 8232
16	17	33	32	1. 410	138. 138	+1. 0112	+1. 0087	+1. 0099	+ 2. 5	−30. 5	+37. 8331
16	17	32	31	1. 020	139. 158	+0. 6593	+0. 6559	+0. 6576	+ 3. 4	−27. 1	+38. 4907
16	16	31	30	1. 048	140. 206	+0. 1194	+0. 1142	+0. 1168	+ 5. 2	−21. 9	+38. 6075
14	16	30	29	1. 130	141. 336	+0. 3034	+0. 2982	+0. 3008	+ 5. 2	−16. 7	+38. 9083
14	14	29	28	1. 574	142. 910	−2. 1168	−2. 1272	−2. 1220	+10. 4	− 6. 3	+36. 7863
14	13	28	27	1. 144	144. 054	+1. 3150	+1. 3110	+1. 3130	+ 4. 0	− 2. 3	+38. 0993
11	11	27	26	0. 980	145. 034	+0. 1433	+0. 1412	+0. 1423	+ 2. 1	− 0. 2	+38. 2416
11	11	26	25	1. 172	146. 206	+0. 8659	+0. 8588	+0. 8624	+ 7. 1	+ 6. 9	+39. 1040
9, 11, 12 Mar. 5	5, 6, 10 Mar. 5	25	24	1. 591	147. 797	−1. 1565*	−1. 1672*	−1. 1618	+10. 7	+17. 6	+37. 9422
7, 9 Mar. 5	5, 6, 10 Mar. 5	24	23	1. 028	148. 825	−0. 4342*	−0. 4398†	−0. 4370	+ 5. 6	+23. 2	+37. 5052
Mar.	Feb.										
1	5	23	‡22	1. 290	150. 115	+1. 8811	+1. 8823	+1. 8818	− 1. 2	+22. 0	+39. 3870
1	5	22	21	1. 036	151. 151	−1. 2537	−1. 2626	−1. 2590	+ 8. 9	+30. 9	+38. 1280
1	4	21	20	0. 594	151. 745	+0. 5689	+0. 5679	+0. 5683	+ 1. 0	+31. 9	+38. 6963
Feb.											
28	4	20	17	1. 352	153. 097	−0. 2656	−0. 2657	−0. 2657	+ 0. 1	+32. 0	+38. 4306
--	4	17	19	1. 368	154. 465	------	+1. 2123	+1. 2123	------	------	+39. 6429
28	3	17	15	1. 416	154. 513	+0. 1642	+0. 1638	+0. 1640	+ 0. 4	+32. 4	+38. 5946
28	3	15	14	0. 880	155. 393	+0. 6223	+0. 6188	+0. 6202	+ 3. 5	+35. 9	+39. 2148
28	3	14	13	0. 388	155. 781	+0. 6775	+0. 6793	+0. 6786	− 1. 8	+34. 1	+39. 8934
	Jan.										
28	30	13	12	0. 617	156. 398	−0. 3386	−0. 3442	−0. 3420	+ 5. 6	+39. 7	+39. 5514
Mar.											
2	30	12	8	3. 782	160. 180	+0. 1086	+0. 1128	+0. 1111	− 4. 2	+35. 5	+39. 6625
2	30	8	11	2. 308	162. 488	-0. 4654	−0. 4530	−0. 4580	−12. 4	+23. 1	+39. 2045
2	27	8	7	0. 447	160. 627	+0. 5344	+0. 5335	+0. 5339	+ 0. 9	+36. 4	+40. 1964
2	27	7	5	2. 852	163. 479	−1. 2466	−1. 2506	−1. 2490	+ 4. 0	+40. 4	+38. 9474
3	26	5	3	2. 565	166. 044	−1. 2186	−1. 2211	−1. 2201	+ 2. 5	+42. 9	+37. 7273
Jan.	Mar.										
24	3	3‡	2	0. 735	166. 779	+2. 4941	+2. 4964	+2. 4950	− 2. 3	+40. 6	+40. 2223
	Jan.										
24	26	2	1	1. 302	168. 081	−0. 4982	−0. 4889	−0. 4945	− 9. 3	+31. 3§	+39. 7278

* The mean of five determinations. † The mean of six determinations.

‡ From B. M.'s 22 to 3, the backward measures are the means of two simultaneous lines; likewise, the forward measures from B. M.'s 3 to 1; to these quantities a weight of 1½ was given.

§ This is the total discrepancy from B. M. 155.

SECTION IV.—*Location and description of permanent bench-marks from Milliken's Bend, La., to Greenville, Miss.*

188.—Described in Section II.

184.—On River View Plantation, Madison Parish, La. The center of head of copper bolt in brick pillar supporting northeast corner of porch of dwelling-house belonging to Citizens' Bank of Louisiana. Situated about 1¼ miles below Milliken's Bend.

179.—On English Field Plantation, three-fourths mile above Milliken's Bend, La. The center of copper bolt in sixth brick from top of foundation, and third one from northwest corner of Mr. H. P. Morancy's dwelling-house.

171.—On Ditchley Plantation, one-fourth mile above Omega post-office, Madison Parish, La. The center of head of copper bolt in brick chimney on north face and near northeast edge of Mrs. Sarah A. Nutt's dwelling-house.

162.—On Henderson Plantation, one-eighth mile above Henderson Landing, in East Carroll Parish, La. The center of head of copper bolt in west face of pillar of dwelling-house owned by Mrs. Emma E. Peck.

161.—On Henderson Plantation, three-fourths mile above Henderson Landing. The center of head of copper bolt in east face of chimney of cabin opposite old gin-house. Marked U. S. B. M.

153.—On Tennessee Plantation, 3½ miles above Ingomar post-office, Issaquena County, Miss. The center of head of copper bolt in brick chimney of cotton-gin. Marked U. S. B. M.

150.—On Forest Home Plantation, about 4 miles above Ingomar post-office. The center of head of copper bolt in southwest face of chimney of dwelling-house.

140.—On Shiloh Plantation, near Landing, Issaquena County, Miss. The center of head of copper bolt in north face of brick chimney of cotton-gin. Marked U. S. B. M.

137.—On Elliston Plantation, near Hay's post-office, Issaquena Company, Miss. The center of head of copper bolt in brick pillar (second one from southwest corner) supporting dwelling-house porch.

128.—On Lockwood Plantation, one-third mile above Tallulah Landing, Issaquena County, Miss. The center of head of copper bolt near southeast corner of brick foundation of dwelling-house.

124.—Two miles above Tallulah Landing, Issaquena County, Miss. The center of head of copper bolt in brick foundation of Tallulah P. O., or better known as "Old Tallulah Court-House."

112.—On Ben Lomond Plantation, Issaquena County, Miss. The center of head of copper bolt in west face of chimney of gin-house just back of Ben Lomond post-office.

105.—On Reserve Plantation, Issaquena County, Miss. The center of head of copper bolt in west face of brick chimney of gin-house, about one-fourth mile from levee and 3½ above Ben Lomond post-office.

95.—On Wade Lawn Plantation, one-fourth mile below Mayersville, Issaquena County, Miss. The center of head of copper bolt in west face of brick chimney at north end of dwelling-house.

90.—On Glen Annie Plantation, about 2 miles above Mayersville, Issaquena County, Miss. The center of head of copper bolt in front face of brick pillar supporting the southwest corner of portico of Col. H. B. Keep's house.

83.—On River Dale Plantation, opposite Arkansas line, Issaquena County, Miss. The center of head of copper bolt in second brick pillar south from north corner of dwelling-house.

70.—On Palmetto Plantation, Washington County, Miss. The center of head of copper bolt in brick pillar at northwest corner of dwelling-house.

65.—On Albemarle Plantation, about a mile below Leota, Washington County, Miss. The center of head of copper bolt in front face of dwelling-house, in second brick below water sill and about the middle of large brick column on left-hand side of entrance to house.

62.—On Maryland Plantation, back of Leota, Washington County, Miss. The center of head of copper bolt in second brick below wood sill, about the middle of north face of dwelling-house.

56.—On D. M. Hill's plantation, near Lake Washington Landing, Washington County, Miss. The top of copper bolt in a block of cement set in the ground about 53 feet back of the levee and 100 feet north of road from Landing to Lake Washington.

46.—On Longwood Plantation, Washington County, Miss. The center of head of copper bolt in west face of gin-house chimney. Marked U. S. B. M.

42.—On Glenora Plantation, Washington County, Miss. The center of head of copper bolt in west face of gin-house chimney.

39.—On Auburn Plantation, Washington County, Miss. The center of head of copper bolt in north face of gin-house brick chimney on Buckner's estate. Marked U. S. B. M.

33.—On Wayside Plantation, near the banks of Lake See, Washington County, Miss. The center of head of copper bolt in brick foundation on right of porch in front side of dwelling-house.

22.—At Refuge, Washington County, Miss. The center of head of copper bolt in second pier on northwest side of Mr. Richardson's store.

19.—On Refuge Plantation, Washington County, Miss. The center of head of copper bolt in gin-house chimney, about 3 feet above ground.

11.—On Highland Plantation, Warfield Point, Washington County, Miss., about 6 miles below Greenville. The top of copper bolt in block of cement placed about 70 feet north of Mr. Warfield's house, near large cotton-wood tree.

8.—A temporary bench on Richardson's plantation, about 2 miles above Warfield Point. The top of an iron spike on a stump 8 feet in diameter and 8 feet high in a cypress swamp.

5.—A temporary bench about $2\frac{1}{4}$ miles below Greenville and abreast of La Grange landing. The top of an iron spike driven vertically into large cotton-wood tree near foot of eastern slope of levee.

2.—Near Greenville, Miss. The center of head of copper bolt in fourteenth course above water sill of C. P. Huntington's gin-house chimney. Marked U. S. B. M.

1.—At Greenville, Miss. On corrugated iron door-sill on north side, near northwest corner of building known as the "Bank Building." The precise point is not marked, but can be defined as the point near the back side and west end of sill, 32.0 centimetres from front face, 5.5 centimetres from door-strip, and 9.0 centimetres from west door-jamb.

SECTION V.—*From Greenville, Miss., to Engineer's bench-mark 84, near Wilkerson's Landing, Miss., opposite Arkansas City, Ark.**

[Executed under the Mississippi River Commission, by J. B. Johnson, Assistant Engineer, in 1880–'81.]

Bench-marks.		Distance between successive bench-marks.	Total distance from Greenville bench-mark.	Difference of height between bench-marks.		Mean of measures.	Total height above average level of Gulf of Mexico (at Biloxi, Miss.).
From	To			Line in North direction.	Line in South direction.		
		Km.	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*
	Greenville No. 1.	0.00	0.00	--------	--------	--------	39.7278
Greenville No. 1.	{537, 538}	1.92	1.92	−0.5693	−{0.5625, 0.5660}	−0.5659	
{537, 538}	88	3.45	5.37	−{1.2982, 1.2926}	−1.2836	−1.2915	37.8704
88	536	1.13	6.50	−0.6679	−0.6675	−0.6677	
536	535	1.98	8.48	+2.9027	+2.9002	+2.9014	
535	534	1.47	9.95	+0.9485	+0.9495	+0.9490	
534	533	1.75	11.68	−{2.3132, 2.3121}	−{2.3185, 2.3101}	−2.3135	
533	532½	1.64	13.34	+0.9798	+0.9842	+0.9820	
532½	{531, 532}	0.79	14.13	−0.6841	−0.6839	−0.6840	
{531, 532}	530	4.08	18.21	+0.5949	+0.5915	+0.5932	

* This table has been prepared from the annual report of the Commission for 1882, pages 73, 74.

SECTION V.—*From Greenville, Miss., to Engineer's bench-mark 84, etc.*—Continued.

Bench-marks.		Distance between successive bench-marks.	Total distance from Greenville bench-mark.	Difference of height between bench-marks.		Mean of measures.	Total height above average level of Gulf of Mexico (at Biloxi, Miss.).
From	To			Line in North direction.	Line in South direction.		
		Km.	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*
530	{529, 528}	3.54	21.75	+0.8029	+0.8079	+0.8054	
{529, 528}	86	2.73	24.48	+0.4903	+0.4896	+0.4900	40.9262
86	{526, 527}	0.26	24.74	+1.7196	+1.7206	+1.7201	
{526, 527}	85	1.83	26.57	−{1.2392, 1.2418}	−{1.2473, 1.2436}	−1.2430	41.4033
85	{523, 524}	1.54	28.11	−0.9870	−0.9840	−0.9855	
{523, 524}	84	4.11	32.22	+1.6246	+1.6184	+1.6215	42.0393

SECTION V.—*Location and description of permanent bench-marks from Greenville, to Wilkerson's Landing, Miss., opposite Arkansas City, Ark.**

Greenville No. 1.—Described in Section IV.

B. M. 88.—Is top of brass bolt in top of stone post, set in southwest corner of field on lands of James Rogers (colored) about 1 mile north of Argyle, Washington County, Miss. Stone is in fence at crossing of new levee and Arkansas City road. The Memphis and Greenville telegraph line here leaves the levee and follows the Arkansas City road. Top of bolt is 3 millimetres above top of stone.

B. M. 86.—Is top of brass bolt in top of stone post, planted on lands of Thomas S. Kennedy (— — — Martin, lessee) 300 metres above Offut's Landing, Washington County, Miss. The stone is in southwest corner of field, 1 metre back of old levee, 25 metres north of new levee, which marks the boundary between Bolivar and Washington Counties, and is therefore in Bolivar County, Miss. Top of bolt is 4 millimetres above top of stone.

B. M. 85.—Is top of brass bolt in top of stone post, set in southeast corner of yard on Thomas S. Kennedy's plantation (John Graves, lessee) at Port Anderson, Bolivar County, Miss. Stone is 25 metres east of a brick cistern at southeast corner of house, and 40 metres southeast of a brick cistern at northeast corner of house. It is 55 metres back from levee, and about 160 metres above an abrupt turn in levee. Top of bolt is 5 millimetres above top of stone.

B. M. 84.—*U. S. Engineer's description*, 1880–'81.—Is top of brass bolt in stone post, set on Lewis Clark's plantation, 1,400 metres below Wilkerson's Landing, Bolivar County, Miss. Stone is just inside of fence, 15 metres back of levee, 10 metres northwest of house of Daniel Braxton (colored), 20 metres north of woods which extend to Port Anderson, some 3 miles below. Top of bolt is 5 millimetres above top of stone.

U. S. C. & G. S. description, 1887.—Is the top of brass bolt in stone post on Mr. Rigley's plantation, which had changed ownership since the above description. The stone was found to be *outside* of fence, 15 metres back of levee and 10 metres northwest of house, occupied now by Benjamin Cole. It is about 6 inches square, projecting 6 inches above the surface of the ground, and has the letters U. S. carved in its upper surface. Top of bolt was found to be only 2 millimetres above top of stone with no indication that it had been broken off or tampered with.

N. B. The data for judging of the accuracy of the levels and the probable errors of the resulting heights will be found in the next appendix, No. 12, Report for 1888, where the line is carried as far as Little Rock, Ark.

* These descriptions are taken from the Mississippi River Commission report for 1882, pages 76 and 77.

APPENDIX No. 12.—1888.

HEIGHTS FROM SPIRIT-LEVELING OF PRECISION BETWEEN ARKANSAS CITY (ON THE MISSISSIPPI RIVER) AND LITTLE ROCK, ARK.

Observations by J. E. McGRATH, Subassistant, in 1887-'88.

Report by CHARLES A. SCHOTT, Assistant.

COMPUTING DIVISION, COAST AND GEODETIC SURVEY,
July 30, 1888.

DEAR SIR: I herewith respectfully submit a report on the results of the spirit-leveling of precision between Arkansas City (on the Mississippi River) and Little Rock, Ark., 1887–'88.

Route of levels.—The line starts from a bench-mark of the Mississippi River Commission opposite Arkansas City, Ark., which is about 18 statute miles above Greenville, Miss., and follows the Little Rock, Mississippi River and Texas Railroad to Little Rock. The total development of the leveling is 184½ kilometres or 114¾ statute miles.

Observer and date of leveling.—The line from opposite Arkansas City to Little Rock was leveled by J. E. McGrath, Subassistant, aided by J. Nelson, Aid, between October 24, 1887 and February 22, 1888.

Instruments.—Geodetic spirit-level No. 2 was used for the whole line, also for the crossing of the Arkansas River at Little Rock, but the crossing of the Mississippi River was effected by means of levels Nos. 2 and 3, used simultaneously. These instruments are described in Appendix No. 15, Coast and Geodetic Survey Report for 1879, and figured on plate No. 52. Rods A_1 and B were used; their construction is shown in the same Report, plate No. 53. The instrumental constants are essentially the same as given in full in my report on the leveling about New York Bay and Harbor (Appendix No. 14; Report for 1887) except that a new eye-piece of lower power (24) was fitted to instrument No. 2, September, 1887, likewise one to No. 3 on the same date, power 25, and a new striding level was placed with No. 3, scale value 3″.9 (October 1887). For instrument No. 2 we have, accordingly: Value of 1 div. striding level, 3″.37; value of 1 turn of micrometer screw, 257″.5; angular value of telemeter threads, 16′ 39″.3; collar inequality as determined by J. E. McGrath at the Coast and Geodetic Survey Office September 19, 1887; *object* end collar larger 1″.490, and after the leveling in Arkansas by the same observer, at St. Louis, Mo., February 22 and March 26, 1888, *object* end collar larger 1″.146 and 0″.900; mean=1″.023, the difference being due to wear during the field operation. The metric rods A_1 and B are of standard length at 19°.4 C. (67°.0 Fahr.) and 22°.1 C. (71°.7 Fahr.) respectively. Index correction of rod A_1 as found at Little Rock before the field-work commenced, $79^{mm}.3$, and after its completion $78^{mm}.2$, and for rod B was found similarly 79.3 and $78^{mm}.2$, the rods being of equal length and wearing alike.

Method of observing.—The whole line was independently leveled in a forward direction by one of the observers and in a backward direction by the second observer. As usual with our instruments of precision, the difference of height between the staff readings depends on the micrometer screw, the "horizon" reading being taken with the bubble of the ether level in the middle of the tube; collimation of line of sight and optical axis is secured at each station by observing with telescope direct and inverted (turned 180° about a horizontal axis); the average distance between the staves was about 210 metres, the instrument being mounted midway between. The general manipulation at each station of the instrument is described in Appendix No. 11, Report for 1880, with the exception of the modification of but one line being run at the time, instead of two simultaneous parallel lines. In crossing the Mississippi River, 23 measures of the difference in height of the marks on each bank were taken simultaneously by two instruments, on two days, and at various hours. The distance across the river was 1129 metres.

Computations.—The field computation was made by the observer, the office computation by F. M. Little, and the reduction-tables and revision by L. A. Bauer. These reductions were made on the printed forms provided for levels of precision and include the computation of the probable errors of the results.

Resulting elevations.—They are here given in the usual form; the initial plane of reference is the average level of the Gulf of Mexico as observed at Biloxi, Miss. (for particulars see my report of August 4, 1887,* on results of leveling between Mobile, Ala. and New Orleans, La., 1885–'86). In order to get the height of the starting mark, the result of the spirit-levels between Greenville, Miss., and bench-mark No. 84, as determined by the Mississippi River Commission in 1880–'81, had to be added to the height of the Greenville mark, at the Bank Building, this being the terminal point on the river of the Coast and Geodetic Survey levels. We have the following data:

	Metres.
Average level of the Gulf of Mexico at Biloxi, Miss	0.0000
B. M. I at Carrollton, La., above average Gulf level	2.6659
B. M. I at Greenville, Miss., above Carrollton B. M.	37.0619
B. M. 84, Mississippi River Commission, near Wilkerson's Landing, Miss., above Greenville B. M.	2.3115
Elevation of B. M. No. 84 below Wilkerson's Landing, Miss., above the Gulf	42.0393

Equal to 137.926 feet.

The precise levels between Biloxi and bench-mark No. 84, opposite Arkansas City, were executed by the Coast and Geodetic Survey, with the exception of the short distance between Greenville, Miss. and bench-mark No. 84 below Wilkerson's Landing, Miss., which was done under the direction of the Mississippi River Commission. Further particulars respecting the character of these operations will be found further on in connection with the discussion of the probable error of the result.

For table of results of levels between New Orleans, La., and bench-mark No. 84 near Wilkerson's Landing, Miss., and for results of precise levels under the Mississippi River Commission during the years 1880–'81 by J. B. Johnson, Assistant Engineer, extending from Coast and Geodetic Survey bench-mark No. 1 at Bank Building at Greenville, Miss., to bench-mark No. 84, (about 1½ kilometres below Wilkerson's Landing, Miss.,) see preceding Appendix No. 11, Coast and Geodetic Survey Report for 1888.

*Appendix No. 9, Report for 1887.

Results of spirit-leveling between mark near Wilkerson's Landing, Miss., opposite Arkansas City, and Little Rock, Ark., 1887-'88.

Date, 1887-'88.	Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Measure forward.	Measure backward.	Mean.	Discrepancy. Partial.	Total accumulated.	Height of bench-mark above average Gulf level (at Biloxi).
			Km.	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
		84	----	0.000	------	------	------	----	0.0	+ 42.0393
Nov. 29	84	82†	0.490	0.490	+0.0262	+0.0229	+0.0246	+3.3	+ 3.3	+ 42.0639
Dec. 1 and 2	82	81	1.189	1.679	—0.2486	—0.2514	—0.2500	+2.8	+ 6.1	+ 41.8139
3	81	53	0.180	1.859	+1.9527	+1.9524	+1.9526	+0.3	+ 6.4	+ 43.7665
Nov. 25	53	F	0.226	2.085	—1.7856	—1.7856	—1.7856	0.0	+ 6.4	+ 41.9809
Nov. 17	53	54	0.940	2.799	—0.2921	—0.2889	—0.2905	—3.2	+ 3.2	+ 43.4760
17	54	55	1.042	3.841	—0.2382	—0.2392	—0.2387	+1.0	+ 4.2	+ 43.2373
17	55	56	1.089	4.930	—0.0037	—0.0067	—0.0052	+3.0	+ 7.2	+ 43.2321
18 19	56	57	0.882	5.812	—0.0295	—0.0275	—0.0285	—2.0	+ 5.2	+ 43.2036
18 19	57	58	1.068	6.880	+0.1613	+0.1597	+0.1605	+1.6	+ 6.8	+ 43.3641
18 19	58	59	0.850	7.730	—0.0185	—0.0203	—0.0194	+1.8	+ 8.6	+ 43.3447
18 19	59	60	0.838	8.568	—0.3078	—0.3029	—0.3054	—4.9	+ 3.7	+ 43.0393
18 19	60	61	0.628	9.196	+0.2182	+0.2173	+0.2178	+0.9	+ 4.6	+ 43.2571
18 19	61	62	1.004	10.200	+0.3972	+0.3975	+0.3974	—0.3	+ 4.3	+ 43.6545
18 30	62	63	1.522	11.722	—0.1402	—0.1435	—0.1418	+3.3	+ 7.6	+ 43.5127
18 30	63	64	1.235	12.957	+0.0118	+0.0135	+0.0126	—1.7	+ 5.9	+ 43.5253
21 28	64	65	0.784	13.741	—0.4152	—0.4166	—0.4159	+1.4	+ 7.3	+ 43.1094
21 28	65	67	1.744	15.485	—0.8655	—0.8593	—0.8624	—6.2	+ 1.1	+ 42.2470
21 26	67	68	1.000	16.485	+0.9965	+0.9951	+0.9958	+1.4	+ 2.5	+ 43.2428
21 26	68	69	0.890	17.375	+0.1439	+0.1430	+0.1434	+0.9	+ 3.4	+ 43.3862
21 26	69	70	1.063	18.438	—0.8453	—0.8484	—0.8468	+3.1	+ 6.5	+ 42.5394
21 26	70	71	1.062	19.500	+0.4152*	+0.4207*	+0.4180	—5.5	+ 1.0	+ 42.9574
21 26	71	72	0.956	20.456	+0.9815	+0.9795	+0.9805	+2.0	+ 3.0	+ 43.9379
22 23	72	73	1.142	21.598	+0.8041	+0.8071	+0.8056	—3.0	0.0	+ 44.7435
26	73	G	0.076	21.674	+0.6284	+0.6286	+0.6285	—0.2	— 0.2	+ 45.3720
22 23	73	74	1.128	22.726	—0.2923	—0.2895	—0.2909	—2.8	— 2.8	+ 44.4526
22 23	74	75	1.134	23.860	—0.4252	—0.4251	—0.4252	—0.1	— 2.9	+ 44.0274
22 26	75	76	1.375	25.235	—0.3861*	—0.3816*	—0.3838	—4.5	— 7.4	+ 43.6436
22 23	76	77	1.138	26.373	—0.0762	—0.0753	—0.0758	—0.9	— 8.3	+ 43.5678
22 23	77	78	1.209	27.582	+0.5210	+0.5254	+0.5232	—4.4	—12.7	+ 44.0910
22 23	78	79	1.218	28.800	+1.3071	+1.3108	+1.3090	—3.7	—16.4	+ 45.4000
22 23	79	80	1.496	30.296	+0.0713	+0.0702	+0.0708	+1.1	—15.3	+ 45.4708
Dec.										
6 14	80	83	0.754	31.050	+0.1126	+0.1141	+0.1134	—1.5	—16.8	+ 45.5842
6 14	83	84	0.716	31.766	—0.1686	—0.1704	—0.1695	+1.8	—15.0	+ 45.4147
6	84	H	0.072	31.838	+0.8922*	+0.8923*	+0.8922	—0.1	—15.1	+ 46.3069
6 14	84	85	0.816	32.582	+1.0277	+1.0284	+1.0280	—0.7	—15.7	+ 46.4427
6 14	85	86	1.015	33.597	—0.5244	—0.5200	—0.5222	—4.4	—20.1	+ 45.9205

* The mean of two determinations.

† Crossing the Mississippi River; results given are the means of twelve determinations.

Results of spirit-leveling between mark near Wilkerson's Landing, Miss., etc.—Continued.

Date, 1887–'88.		Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Measure forward.	Measure backward.	Mean.	Discrepancy. Partial.	Total accumulated.	Height of bench-mark above average Gulf level (at Biloxi).
Dec.				*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
6	14	86	88	2.481	36.078	+0.0426	+0.0439	+0.0432	−1.3	−21.4	+ 45.9637
10	14	88	89	1.150	37.228	+0.6665	+0.6696	+0.6680	−3.1	−24.5	+ 46.6317
10	14	89	90	1.362	38.590	+0.3035	+0.3046	+0.3040	−1.1	−25.6	+ 46.9357
10	13	90	91	1.369	39.959	−0.3120	−0.3104	−0.3112	−1.6	−27.2	+ 46.6245
10	13	91	92	1.086	41.045	−0.5046	−0.5034	−0.5040	−1.2	−28.4	+ 46.1205
10	13	92	93	1.424	42.469	+2.1398	+2.1392	+2.1395	+0.6	−27.8	+ 48.2600
12	13	93	94	0.838	43.307	−0.0112	−0.0119	−0.0116	+0.7	−27.1	+ 48.2484
12	13	94	95	0.732	44.039	+0.8128	+0.8138	+0.8133	−1.0	−28.1	+ 49.0617
12	13	95	96	0.493	44.532	+0.5488	+0.5476	+0.5482	+1.2	−26.9	+ 49.6099
12	13	96	97	0.654	45.186	−1.7512	−1.7539	−1.7526	+2.7	−24.2	+ 47.8573
12	13	97	98	0.743	45.929	+0.3721	+0.3700	+0.3710	+2.1	−22.1	+ 48.2283
12	13	98	99	1.258	47.187	+0.1392	+0.1439	+0.1416	−4.7	−26.8	+ 48.3699
15		99	I	0.077	47.264	+1.2031	+1.2038	+1.2034	−0.7	−27.5	+ 49.5733
15	22	99	100	0.926	48.113	−0.2119*	−0.2139*	−0.2129	+2.0	−24.8	+ 48.1570
15	22	100	101	0.804	48.917	+0.7621*	+0.7608*	+0.7614	+1.3	−23.5	+ 48.9184
15	22	101	102	0.780	49.697	+0.3766	+0.3769	+0.3768	−0.3	−23.8	+ 49.2952
15	22	102	103	0.810	50.507	+0.5731	+0.5685	+0.5708	+4.6	−19.2	+ 49.8660
15	22	103	104	1.004	51.511	−0.3915	−0.3950	−0.3932	+3.5	−15.7	+ 49.4728
15	22	104	105	1.862	53.373	−0.3630*	−0.3625*	−0.3628	−0.5	−16.2	+ 49.1100
16	21	105	106	1.202	54.575	−0.6529	−0.6510	−0.6520	−1.9	−18.1	+ 48.4580
16	21	106	107	1.195	55.770	−0.2159*	−0.2216*	−0.2188	+5.7	−12.4	+ 48.2392
16	21	107	108	1.126	56.896	+0.4410	+0.4425	+0.4418	−1.5	−13.9	+ 48.6810
11 } 21 }	Jan. 3	108	109	1.162	58.058	+0.3204*	+0.3163*	+0.3184	+4.1	− 9.8	+ 48.9994
Dec.											
16	21	109	110	1.224	59.282	−0.8336	−0.8313	−0.8324	−2.3	−12.1	+ 48.1670
16	21	110	111	1.305	60.587	+0.4083	+0.4087	+0.4085	−0.4	−12.5	+ 48.5755
17	21	111	112	0.950	61.537	−0.0511	−0.0522	−0.0516	+1.1	−11.4	+ 48.5239
17	21	112	113	0.913	62.450	+0.4215	+0.4179	+0.4197	+3.6	− 7.8	+ 48.9436
17	21	113	114	0.918	63.368	+0.2862	+0.2872	+0.2867	−1.0	− 8.8	+ 49.2303
17	21	114	115	0.982	64.350	+0.8434	+0.8434	+0.8434	0.0	− 8.8	+ 50.0737
17	21	115	116	1.087	65.437	−0.0064	−0.0048	−0.0056	−1.6	−10.4	+ 50.0681
17	21	116	117	1.216	66.653	+0.3007*	+0.2953*	+0.2980	+5.4	− 5.0	+ 50.3661
Jan. 2	19	117	118	1.532	68.185	+1.0729	+1.0689	+1.0709	+4.0	− 1.0	+ 51.4370
Dec.	Jan.										
23	2	118	119	1.095	69.280	+0.9698	+0.9663	+0.9680	+3.5	+ 2.5	+ 52.4050
23	2	119	120	0.922	70.202	+0.3807	+0.3809	+0.3808	−0.2	+ 2.3	+ 52.7858
23	2	120	121	1.113	71.315	−0.5191	−0.5192	−0.5192	+0.1	+ 2.4	+ 52.2666
23	2	121	122	1.204	72.519	+1.6128	+1.6129	+1.6128	−0.1	+ 2.3	+ 53.8794
31		122	J	0.074	72.593	+0.4250	+0.4254	+0.4252	−0.4	+ 1.9	+ 54.3046

* The mean of two determinations.

Results of spirit-leveling between mark near Wilkerson's Landing, Miss., etc.—Continued.

Date, 1887–'88.		Bench-marks.		Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks.			Discrepancy.		Height of bench-mark above average Gulf level (at Biloxi).
		From	To			Measure forward.	Measure backward.	Mean.	Partial.	Total accumulated.	
Dec.	Jan.			*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
23	30	122	123	1.176	73.695	+0.3158	+0.3160	+0.3159	−0.2	+ 2.1	+ 54.1953
23	30	123	124	1.164	74.859	−0.2061	−0.2094	−0.2078	+3.3	+ 5.4	+ 53.9875
24	30	124	125	1.292	76.151	+0.4583	+0.4576	+0.4580	+0.7	+ 6.1	+ 54.4455
24	30	125	126	1.440	77.591	−0.0353	−0.0420	−0.0386	+6.7	+12.8	+ 54.4069
24	30	126	127	1.402	78.993	+0.6908	+0.6928	+0.6918	−2.0	+10.8	+ 55.0987
24	30	127	128	1.196	80.189	−0.4259	−0.4306	−0.4282	+4.7	+15.5	+ 54.6705
24	29	128	129	1.164	81.353	+1.2143	+1.2150	+1.2146	−0.7	+14.8	+ 55.8851
24	29	129	130	1.444	82.797	+0.2510	+0.2466	+0.2488	+4.4	+19.2	+ 56.1339
27	29	130	131	1.364	84.161	−0.4810	−0.4778	−0.4794	−3.2	+16.0	+ 55.6545
27	28	131	132	1.381	85.542	−0.0395	−0.0372	−0.0384	−2.3	+13.7	+ 55.6161
27	28	132	133	1.373	86.915	+0.8993	+0.9022	+0.9008	−2.9	+10.8	+ 56.5169
27	28	133	134	1.318	88.233	+0.6507	+0.6502	+0.6504	+0.5	+11.3	+ 57.1673
27	28	134	135	1.248	89.481	−1.3459	−1.3501	−1.3480	+4.2	+15.5	+ 55.8193
Jan.											
5	11	135	136	1.298	90.779	+0.1714	−0.1682	+0.1698	+3.2	+18.7	+ 55.9891
5	7	136	137	1.637	92.416	+1.6410	+1.6414	+1.6412	−0.4	+18.3	+ 57.6303
5	7	137	138	1.331	93.747	+1.5505	+1.5540	+1.5522	−3.5	+14.8	+ 59.1825
5	7	138	139	1.333	95.080	+0.0919	+0.0895	+0.0907	+2.4	+17.2	+ 59.2732
5	7	139	140	1.318	96.398	+0.7445	+0.7397	+0.7421	+4.8	+22.0	+ 60.0153
5	28	140	141	1.312	97.710	+0.1338	+0.1319	+0.1328	+1.9	+23.9	+ 60.1481
6	28	141	142	1.577	99.287	+0.9622	+0.9571	+0.9596	+5.1	+29.0	+ 61.1077
6	27	142	143	0.830	100.117	−0.5244	−0.5281	−0.5262	+3.7	+32.7	+ 60.5815
6	27	143	K	0.348	100.465	+0.8307	+0.8304	+0.8306	+0.3	+33.0	+ 61.4121
6	27	143	146	3.133	103.250	−1.2733	−1.2762	−1.2748	+2.9	+35.6	+ 59.3067
6	27	146	147	1.085	104.335	+1.1699	+1.1665	+1.1682	+3.4	+39.0	+ 60.4749
13	14	147	148	1.364	105.699	+0.7403	+0.7416	+0.7410	−1.3	+37.7	+ 61.2159
13	14	148	149	0.994	106.693	+0.5308	+0.5321	+0.5314	−1.3	+36.4	+ 61.7473
13	14	149	150	0.704	107.397	−0.4353	−0.4319	−0.4336	−3.4	+33.0	+ 61.3137
13	14	150	151	0.887	108.284	+1.1829	+1.1843	+1.1836	−1.4	+31.6	+ 62.4973
14	14	151	152	1.222	109.506	−0.2273	−0.2241	−0.2257	−3.2	+28.4	+ 62.2716
	Feb.										
30	7	152	153	0.911	110.417	−0.0995	−0.0998	−0.0996	+0.3	+28.7	+ 62.1720
30	7	153	154	0.989	111.406	−0.1249	−0.1250	−0.1250	+0.1	+28.8	+ 62.0470
30	7	154	155	0.766	112.172	+1.0677	+1.0659	+1.0668	+1.8	+30.6	+ 63.1138
30	7	155	156	1.208	113.380	+0.5060	+0.5109	+0.5084	−4.9	+25.7	+ 63.6222
30	7	156	157	1.010	114.390	+0.6073	+0.6096	+0.6084	−2.3	+23.4	+ 64.2306
31	7	157	158	1.194	115.584	−1.4038	−1.4046	−1.4042	+0.8	+24.2	+ 62.8264
31	6	158	159	0.896	116.480	+4.9760	+4.9734	+4.9747	+2.6	+26.8	+ 67.8011
Feb. 8		159	N	0.100	116.580	+0.2648	+0.2647	+0.2648	+0.1	+26.9	+ 68.0659
31	6	159	160	1.002	117.482	+1.4434	+1.4445	+1.4440	−1.1	+25.7	+ 69.2451

***Results of spirit-leveling between mark near Wilkerson's Landing, Miss., etc.*—Continued.**

Date, 1887–'88.		Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Measure forward.	Measure backward.	Mean.	Discrepancy. Partial.	Discrepancy. Total accumulated.	Height of bench-mark above average Gulf level (at Biloxi).
				Km.	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
Feb. 6		160	I.	0.099	117.581	+1.8451	+1.8451	+1.8451	0.0	+25.7	+71.0902
31	6	160	161	0.890	118.372	—0.5691	—0.5657	—0.5674	—3.4	+22.3	+68.6777
31	6	161	162	0.838	119.210	+1.5718	+1.5722	+1.5720	—0.4	+21.9	+70.2497
31	6	162	163	0.910	120.120	—1.7814	—1.7798	—1.7806	—1.6	+20.3	+68.4691
31	6	163	164	0.964	121.084	+1.0515	+1.0508	+1.0512	+0.7	+21.0	+69.5203
31	6	164	165	0.973	122.057	—0.5581	—0.5608	—0.5594	+2.7	+23.7	+68.9609
Feb.											
1	4	165	166	1.372	123.429	+0.1943	+0.1937	+0.1940	+0.6	+24.3	+69.1549
1	4	166	167	1.354	124.783	—2.6073	—2.6128	—2.6100	+5.5	+29.8	+66.5449
1	4	167	168	1.320	126.103	+6.0755	+6.0707	+6.0731	+4.8	+34.6	+72.6180
1	4	168	169	1.412	127.515	—0.8186	—0.8217	—0.8202	+3.1	+37.7	+71.7978
1	4	169	170	1.288	128.803	+4.1707	+4.1683	+4.1695	+2.4	+40.1	+75.9673
1	4	170	171	1.184	129.987	+1.2282*	+1.2222*	+1.2252	+6.0	+46.1	+77.1925
1	4	171	172	0.968	130.955	+4.4073	+4.4070	+4.4072	+0.3	+46.4	+81.5997
1	4	172	173	1.187	132.142	+0.7103	+0.7073	+0.7088	+3.0	+49.4	+82.3085
1	4	173	174	1.345	133.487	+9.4482	+9.4455	+9.4468	+2.7	+52.1	+91.7553
2		174	175	1.438	134.925	+6.6664	+6.6642	+6.6653	+2.2	+54.3	+98.4206
2		175	176	1.466	136.391	+2.8575	+2.8534	+2.8554	+4.1	+58.4	+101.2760
2		176	177	1.394	137.785	+4.3836	+4.3791	+4.3814	+4.5	+62.9	+105.6574
2		177	52	0.898	138.683	—1.6929	—1.6920	—1.6924	—0.9	+62.0	+103.9650
Nov.											
15		52	E	0.124	138.807	—0.6017*	—0.6018*	—0.6018	+0.1	+62.1	+103.3632
15		E	51	0.144	138.951	+0.4685	+0.4687	+0.4686	—0.2	+61.9	+103.8318
15		51	50	0.858	139.809	—0.7141	—0.7141	—0.7141	0.0	+61.9	+103.1177
15		50	49	0.907	140.716	+2.5235	+2.5236	+2.5236	—0.1	+61.8	+105.6413
10	9	49	48	0.846	141.562	—1.5761	—1.5755	—1.5758	—0.6	+61.2	+104.0655
10	9	48	47	1.020	142.582	—2.8944	—2.8957	—2.8950	+1.3	+62.5	+101.1705
10	9	47	46	0.986	143.568	+5.4300	+5.4337	+5.4318	—3.7	+58.8	+106.6023
10	9	46	45	0.833	144.401	—1.6218	—1.6243	—1.6230	+2.5	+61.3	+104.9793
10	9	45	44	0.994	145.395	—5.3583	—5.3611	—5.3597	+2.8	+64.1	+99.6196
10	9	44	43	1.230	146.625	—7.5001	—7.5033	—7.5017	+3.2	+67.3	+92.1179
10	9	43	42	0.644	147.269	—1.4633	—1.4630	—1.4632	—0.3	+67.0	+90.6547
10	9	42	41	0.356	147.625	+0.7199	+0.7176	+0.7188	+2.3	+69.3	+91.3735
16		41	D	0.183	147.808	+2.0736	+2.0733	+2.0734	+0.3	+69.6	+93.4469
10	9	41	40	0.972	148.597	—6.2259	—6.2240	—6.2250	—1.9	+67.4	+85.1485
11	8	40	39	1.109	149.706	—6.6861	—6.6908	—6.6884	+4.7	+72.1	+78.4601
11	8	39	38	1.066	150.772	—5.7058	—5.7062	—5.7060	+0.4	+72.5	+72.7541
11 16	11 16	38	37	1.118	151.890	—2.2460*	—2.2512*	—2.2486	+5.2	+77.7	+70.5055
11		37	36	0.498	152.388	+2.7988	+2.7975	+2.7982	+1.3	+79.0	+73.3037

* The mean of two determinations.

Results of spirit-leveling between mark near Wilkerson's Landing, Miss., etc.—Continued.

Date, 1887–'88.		Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Height of difference between bench-marks. Measure forward.	Measure backward	Mean.	Discrepancy. Partial.	Total accumulated.	Height of bench-mark above average Gulf level (at Biloxi).
Nov.				*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
11	8	36	35	1.030	153.418	+1.8646	+1.8632	+1.8639	+1.4	+80.4	+ 75.1676
12	8	35	34	1.050	154.468	+1.3722	+1.3689	+1.3706	+3.3	+83.7	+ 76.5382
11	8	34	33	1.047	155.515	—5.7445	—5.7454	—5.7450	+0.9	+84.6	+ 70.7932
12	8	33	32	0.986	156.501	+1.9021	+1.9013	+1.9017	+0.8	+85.4	+ 72.6949
12	7	32	31	1.292	157.793	+0.9799	+0.9761	+0.9780	+3.8	+89.2	+ 73.6729
12	7	31	30	1.014	158.807	—1.1811	—1.1847	—1.1829	+3.6	+92.8	+ 72.4900
12	7	30	29	1.014	159.821	—1.4067	-1.4025	—1.4046	—4.2	+88.6	+ 71.0854
14	7	29	28	0.892	160.713	+4.1625	+4.1632	+4.1628	—0.7	+87.9	+ 75.2482
14	7	28	27	0.904	161.617	—0.5882	—0.5875	—0.5878	—0.7	+87.2	+ 74.6604
14	7	27	26	0.890	162.507	+1.4498	+1.4523	+1.4510	—2.5	+84.7	+ 76.1114
14	7	26	25	1.036	163.543	—0.5896	—0.5886	—0.5891	—1.0	+83.7	+ 75.5223
3	2	25	24	0.603	164.146	—0.5632	—0.5650	—0.5641	+1.8	+85.5	+ 74.9582
3	2	24	23	1.067	165.213	+2.7032	+2.7035	+2.7034	—0.3	+85.2	+ 77.6616
3		23	C	0.120	165.333	+0.6263	+0.6263	+0.6263	0.0	+ 85.2	+ 78.2879
3	2	23	22	0.628	165.841	—2.5959	—2.5971	—2.5965	+1.2	+86.4	+ 75.0651
3	2	22	21	0.966	166.807	+1.1936	+1.1948	+1.1942	—1.2	+85.2	+ 76.2593
3	2	21	20	1.056	167.863	+0.9986	+0.9978	+0.9982	+0.8	+86.0	+ 77.2575
	Oct.										
1	31	20	19	1.170	169.033	—1.2114	—1.2143	—1.2128	+2.9	+88.9	+ 76.0447
1	31	19	18	1.192	170.225	+1.5133	+1.5119	+1.5126	+1.4	+90.3	+ 77.5573
1	31	18	17	0.982	171.207	+1.1377	+1.1407	+1.1392	—3.0	+87.3	+ 78.6965
1	31	17	16	0.890	172.097	+0.4621	+0.4646	+0.4634	—2.5	+84.8	+ 79.1599
1	31	16	15	1.062	173.159	+1.0429	+1.0455	+1.0442	—2.6	+82.2	+ 80.2041
Nov.											
1		15	II	0.160	173.319	+0.6365	+0.6370	+0.6368	—0.5	+81.7	+ 80.8409
Oct.											
28	27	15	14	0.625	173.784	+1.1656	+1.1655	+1.1656	+0.1	+82.3	+ 81.3697
28	27	14	13	1.092	174.876	—5.4861	—5.4883	—5.4872	+2.2	+84.5	+ 75.8825
28	27	13	12	0.866	175.742	—0.6991	—0.6988	—0.6990	—0.3	+84.2	+ 75.1835
28	27	12	11	1.062	176.804	+6.3525	+6.3487	+6.3506	+3.8	+88.0	+ 81.5341
28	27	11	10	1.189	177.993	+1.9791*	+1.9750*	+1.9770	+4.1	+92.1	+ 83.5111
28	26	10	9	0.992	178.985	—6.1163	—6.1142	—6.1152	—2.1	+90.0	+ 77.3959
28	26	9	8	0.967	179.952	—0.7650	—0.7664	—0.7657	+1.4	+91.4	+ 76.6302
29		8	7	0.796	180.748	+0.4730	+0.4743	+0.4736	—1.3	+90.1	+ 77.1038
29		7	6	0.603	181.351	+0.5315	+0.5345	+0.5330	—3.0	+87.1	+ 77.6368
Oct. 29 } Nov. 4 }	26	6	5	1.004	182.355	+4.0266*	+4.0274*	+4.0270	—0.8	+86.3	+ 81.6638
Nov.											
29	26	5	3 or I	1.040	183.395	—1.6132	—1.6119	—1.6126	—1.3	+85.0	+ 80.0512

*The mean of two determinations.

Results of spirit-leveling between mark near Wilkerson's Landing, Miss., etc.—Continued.

Date, 1887–'88.	Bench-marks. From	Bench-marks. To	Distance between successive bench-marks.	Distance from initial mark.	Difference of height between bench-marks. Measure forward.	Measure backward.	Mean.	Discrepancy. Partial.	Discrepancy. Total accumulated.	Height of bench-mark above average Gulf level (at Biloxi).
Oct.			*Km.*	*Km.*	*Metres.*	*Metres.*	*Metres.*	*Mm.*	*Mm.*	*Metres.*
25	3 or I	4	0.284	183.679	+2.7759	+2.7753	+2.7756	+0.6	+85.6	+ 82.8268
25	4	A	0.808	184.487	+7.9586*	+7.9566*	+7.9576	+2.0	+87.6	+ 90.7844
SUPPLEMENTARY LINES.										
Oct.										
25	3 or I	2	0.186	183.581	−3.7889	−3.7882	−3.7886	−0.7	+84.3	+ 76.2626
24	2	1 †	0.549	184.130	+0.0753	+0.0814	+0.0784	−6.1	+78.2	+ 76.3410
24	1	West Base	0.362	184.492	+1.4014	+1.4018	+1.4016	−0.4	+77.8	+ 77.7426
25	A	B	0.098	184.585	−0.4037	−0.4032	−0.4034	−0.5	+87.1	+ 90.3810
Feb.										
11	B	O	0.176	184.761	−2.8831	−2.8835	−2.8833	+0.4	+87.5	+ 87.4977

* The mean of two determinations.

† Crossing the Arkansas River; results given are the means of three determinations.

N. B.—To convert metres into feet use the relation 1 metre = 3.2808333 feet.

Location and description of bench-marks between mark opposite Arkansas City on the Mississippi River and Little Rock, Ark.

*Bench-mark No. 84.**—United States permanent bench-mark of the Mississippi River Commission (see their Report of 1882, page 76). It is the top of brass bolt in stone post on Mr. Rigby's plantation, 1,400 metres below Wilkerson's Landing, Bolivar County, Miss. Stone is just outside of fence, 15 metres back of levee and 10 metres northwest of house occupied by Benjamin Cole. It is about 6 inches square, projecting 6 inches above the ground, and has the letters U. S. carved on its upper surface.

F.—At Arkansas City, Desha County, Ark. The bottom of a square cavity cut in the top of an 8 by 8 inch granite post set in the ground about 2 metres south of west corner of small house, which is occupied by the engineers of the Little Rock, Mississippi River and Texas Railroad; this house is the first one southwest of the railroad station. The letters U. S. B. M. are cut on the top of the stone.

G.—At McGehee Station, Desha County, Ark. The center of cross cut in the head of copper bolt, which is leaded, horizontally, into a brick of the chimney on the north side of a small white-washed house west of the line of the Little Rock, Mississippi River and Texas Railroad. The brick is in the ninth course from the ground; the house may also be described as the first one south of the road crossing, south of trestle No. 575, and the seventh one north of A. McGehee's store, used as the station and post-office.

H.—At Tillar, Drew County, Ark. The center of cross cut on head of copper bolt leaded, horizontally, into a brick of the chimney at the back of H. L. Henry & Bro.'s store. The brick is the eleventh one from the ground and third one east of side of house.

I.—At Walnut Lake, Desha County, Ark. The center of cross cut on a 2½-inch copper bolt leaded, horizontally, into a brick on the west side of the chimney on the north end of Mr. R. A. Picken's dwelling-house. The brick is in the eighteenth course from the ground.

J.—At Varner, Lincoln County, Ark. The bottom of a square cavity cut in top of

* Described also in preceding appendix, No. 11, Report for 1888.

granite post set about 2 feet west of the extreme east corner of the front yard of Mr. R. R. Rice's residence. The house is a large white frame structure, about 200 yards southeast of Varner station. The bench is marked thus: $\overset{\text{U. S.}}{\underset{\text{B. M.}}{\square}}$

K.—At Noble Lake, Jefferson County, Ark. Is the bottom of a square cavity cut in top of a 6 by 6 inch granite post set at the southeast corner of the north extension of the platform of the Little Rock, Mississippi River and Texas Railroad station. Marked thus: $\overset{\text{U. S.}}{\underset{\text{B. M.}}{\square}}$

N.—At Pine Bluff, Jefferson County, Ark. Is the bottom of a square cavity cut in top of a 6 by 6 inch granite post, which is set in the front yard, at the southeast corner, of a house belonging to Mr. John Bell, this house being at the intersection of Oak street and West Fourth avenue, and is No. 803 on West Fourth avenue. The top of the post is marked thus: $\overset{\text{U. S.}}{\underset{\text{B. M.}}{\square}}$

L.—At Pine Bluff. Jefferson County, Ark. Center of cross cut on head of copper bolt leaded, horizontally, into a brick on the south side of the State Branch Normal School. The brick is in the fourth course below the sill of the first window east of the piazza. The school is situated just west of the city limits.

E.—Near mile-post 85 of the Little Rock, Mississippi River and Texas Railroad. Is the bottom of a square cavity cut in the top of a granite post set about 6 metres west of the track of the Little Rock, Mississippi River and Texas Railroad, and about 23 metres south of the second telegraph pole on the west side of the track south of the mile-post 85. The post is dressed down to 6 by 6 inches and its top marked thus: $\overset{\text{U. S.}}{\underset{\text{B. M.}}{\square}}$

D.—At Redfield, Jefferson County, Ark. Is the bottom of a square cavity cut in the top of a 6 by 6 inch granite post set in the northeast corner of a small front yard between J. Converse's blacksmith shop and store. The post projects about 4 inches above the ground and its top is marked thus: $\overset{\text{U. S.}}{\underset{\text{B. M.}}{\square}}$

C.—At Wrightsville, Pulaski County, Ark. The bottom of a square cavity cut in limestone block which is set in the ground near the southeast end of the platform at the Little Rock, Mississippi River and Texas Railroad station. The stone is just west of the flight of stairs leading up to the platform from the south; the top is beveled and has the letters U. S. B. M. cut in the sides.

H.—A secondary bench-mark between Sweet Home and Wrightsville, Pulaski County, Ark. Is the top of a brass nail almost in the center of an equilateral triangle formed by three copper nails in the top of the southwest block which supports the platform immediately in front of section-house No. 2 of the Little Rock, Mississippi River and Texas Railroad. This section-house is tween mile-posts 106 and 107 and is the one occupied by the section foreman.

I or 3.—A secondary bench-mark at Little Rock, Pulaski County, Ark. Is the bottom of a square cavity cut in the stone door-sill of the middle door, at the west end of it, of the brick building occupied by Whittemore & Gordon, pork brokers, at the foot of Commerce street on the bank of the Arkansas River.

A.—At Little Rock, Pulaski County, Ark. The center of cross cut in the granite substructure of the east face of the United States custom-house and post-office. It is beneath the water-table course of masonry and its center is about 13¾ inches north and about 5½ inches above the upper corner of the north line of the basement window nearest to Second street.

B.—Same place as *A.* A rectangular cavity cut on the north side of the granite coping of wall inclosing the small sunken area immediately in front of the basement window referred to above. The bench is designated by the letters U. S. B. M.

O.—At Little Rock, Pulaski County, Ark. Bottom of a square cavity cut in the top of a 6 by 6 inch granite post set near the main entrance of the State Capitol. This post is about 29½ inches south and about 33½ inches west of the southwest corner of the stone porch.

West Base.—On the north bank of the Arkansas River, near the east end of Argenta, Pulaski County, Ark. A square cut on the extreme south end of the west monument of the United States Engineer's base-line, and is marked U. S. B. M.

Accuracy of the preceding results for heights.

The accuracy of a measure being inversely proportional to its mean or to its probable error, we shall consider the latter for each of the separate lines connecting the Gulf level with the height of Little Rock, Ark. The probable error of leveling is based upon the discrepancy between the results of the forward and of the backward operations for the various bench-marks in the line, and although not representing the whole probable error in consequence of the presence of unknown constant errors which come out only at check crossings of independent lines of levels, we have at present no other means of a more rigid determination.

Let $r_{,}$ and $r_{,,}$ equal the average probable error of a single and of a double leveling (forward and backward independently), respectively, for unit of length or for one kilometre. Hence

$$r_{,} = 0.675\sqrt{\frac{1}{2n}\left[\frac{d\,d}{s}\right]} \qquad \text{and} \qquad r_{,,} = \frac{r_{,}}{\sqrt{2}}$$

Also, let r equal the probable error from *double* leveling of a line of length l, between initial and terminal marks expressed in kilometres. Then

$$r = r_{,,}\sqrt{l}$$

The table below gives these quantities for each of the seven lines composing the whole distance and the final probable error of the mark at Little Rock above the average Gulf level by their combination, allowing $\pm 25^{mm}$ for the probable error in the adopted level of the Gulf at Biloxi, Miss.:

	Line of levels.	$r_{,}$	$r_{,,}$	l	r
		Mm.	*Mm.*	*Km.*	*Mm.*
1	Biloxi, Miss., to New Orleans (Carrollton). Observer, J. B. Weir, 1885–'86. Report of August 4, 1887. [App. 9. Report for 1887.]	±0.88	±0.62	139	± 7.3
2	New Orleans (Carrollton) to Red River Landing,* La. Observer, A. Braid, 1879–'80. MS report of July 18, 1881.†	1.65	1.17	299	20.1
3	Red River Landing to opposite Rodney,‡ Miss. Observer, A. Braid. Report as above.†	1.67	1.18	163	15.1
4	Opposite Rodney to Milliken's Bend,§ La. Observer, J. B. Weir, 1880–'81. Report as above.	1.59	1.12	103	11.4
5	Milliken's Bend to Greenville,‖ Miss. Observers, O. H. Tittmann and J. B. Weir, 1880. Report as above.	2.02	1.43	167	18.5
6	Greenville to opposite Arkansas City,¶ Ark. Observer, J. B. Johnson, Assistant Engineer, Mississippi River Commission, 1880–'81.	1.03	0.73	32	4.2
7	Opposite Arkansas City to Little Rock,** Ark. Observer, J. E. McGrath, 1887–'88.	1.21	0.86	185	11.6

* Temporary bench-mark No. 127.

† The values for $r_{,}$ and $r_{,,}$ as originally given in my report of 1881 are now *increased* by their fourth part to allow approximately for want of independence in results from two parallel and *simultaneous* lines.

‡ Bench-mark LXXIII. ‖ Bench-mark No. 1. ** Bench-mark A.

§ Bench mark No. 188. ¶ Bench-mark No. 84.

Hence probable error of resulting height of bench-mark A at Custom-House and Post-Office at Little Rock $= \sqrt{[(25.0)^2 + (7.3)^2 + (20.1)^2 + (15.1)^2 + (11.4)^2 + (18.5)^2 + (4.2)^2 + (11.6)^2]} = \pm 44^{mm}.0$ or ± 1.73 inches.

We have the probable error of height assigned to bench-mark No. 84 on the east bank of the Mississippi, about 1½ kilometres below Wilkerson's Landing, equal to $\pm 42^{mm}.4$; also *mean* error per kilometre for a single measure of our line between mark opposite Arkansas City and Little Rock, $m_1 = \pm 1.84^{mm}$, which quantity (mean error per km.) is advantageously used for comparative statements of the uncertainty of lines of levels.

Yours, respectfully,

CHAS. A. SCHOTT,
Assistant in charge Computing Division.

MR. B. A. COLONNA,
Assistant in charge Office and Topography.

APPENDIX No. 13.—1888.

DIFFERENTIAL METHOD OF COMPUTING THE APPARENT PLACES OF STARS FOR DETERMINATIONS OF LATITUDE.

By E. D. PRESTON, Assistant.

PREFATORY NOTE.

COAST AND GEODETIC SURVEY OFFICE,
Washington, December 17, 1888.

In the computation of the latitudes of fourteen stations occupied during the year 1887, Mr. E. D. Preston, Subassistant, found it desirable to shorten the labor of computing the apparent declinations of the stars observed, and for this purpose made an investigation looking to the introduction of a differential method.

This method, upon application, he found superior to the logarithmic one, saving both time and labor in computation. It has been deemed well, therefore, to present an account of it in this appendix.

DIFFERENTIAL METHOD OF COMPUTING THE APPARENT PLACES OF STARS FOR LATITUDE WORK.

When a number of stations have been occupied during a season for the determination of latitude, the necessary reduction of the stars from mean to apparent positions requires considerable time. With the view of accomplishing the task sooner as well as making the work much less laborious, and at the same time having an accuracy fully equal to the requirements of the case, the following investigation was made. Although the superiority of this method is most marked when the observations extend over only three or four days, and when several stations with long star lists are to be reduced at one time, yet in any case it is considerably shorter than the usual logarithmic method. Little is gained by observing a star more than three times; and with the improved mean star places now available and allowing a probable error of observation of $0''.50$ for an experienced observer, three evenings' work will reduce the uncertainty of the latitude to about 10 feet. So that this method may be employed nearly always with great advantage.

The computation of the apparent places of stars for the dates of observation may be abridged in two ways; first, in using Crelle's tables instead of making the usual four-place logarithmic computation, and, second, after having one date getting a neighboring date by the application of differential quantities derived from the usual formulæ.

If we consider the tabular differences of the quantities that vary with the date as the differential co-efficients of the quantities with respect to the time at the date already computed, we have the following formulæ as representing the change in declination between the two dates:

$$-gdG \sin (G+\alpha)+dg \cos (G+\alpha)$$
$$[-hdH \sin (H+\alpha)+dh \cos (H+\alpha)] \sin \delta$$
$$di \cos \delta$$

The following relations exist between the independent star numbers:

$$G=\tan^{-1}\frac{B}{KA} \qquad H=\tan^{-1}\frac{C}{D} \qquad g=\frac{B}{\sin G} \qquad h=\frac{C}{\sin H} \qquad i=C \tan \omega$$

Where the letters have the signification given in the American Ephemeris, K is the precession constant 20″.0533.

The greatest departure from a uniform change for a 5-day period in B and A is due to terms depending on the moon's longitude. The terms depending on the longitude of the sun, of the moon's ascending node, and on the longitude of the sun's and moon's perigees, being either quite regular for a 5-day period or else being extremely small. In 1887 G does not change as much as 3°; g changes less than 0″.5.

The tan of H varies inversely as the tangent of the sun's mean longitude. Hence H varies nearly uniformly throughout the year, changing about 1° daily. h depends on the same quantity and has its maximum values at the solstices and its minimum ones at the equinoxes. For a 5-day period it departs little from a uniform change. i varies also with the sun's longitude and has its maximum with the minimum h and *vice versa*. The greatest daily change in i is not much more than 0″.10, while that of h is very much less.

The value of G is in general principally affected by changes in terms depending on the sun's and moon's longitude and on the longitude of the moon's ascending node. The latter has a daily motion of 3′. The first two have a daily motion of about 1° and 13°, respectively. *Tan* G varies directly as B and inversely as A, and since the former depends on the cosines and the latter on the sines of the above functions, they do not both change rapidly at the same time. At 90° cos ☊ changes .005 in five days and the change in cos 2☊ may be neglected. When ☉=45° cos 2☉ has a change of .087. For an equal period and position cos 2☾ changes about 1 unit. The terms in which these quantities enter will therefore vary by 0″.05, 0″.05, and 0″.09 respectively. Hence the greatest change in B comes from the change in the moon's longitude. In case of all these changes having their maximum at the same time, and tending in the same direction, the value of B would only be changed by about one-fiftieth part of itself, and since $d \tan^{-1} y=\frac{dy}{1+y^2}$ the change in G dependent on B will not be more than about 1°.

The longitude of the moon's ascending node does not pass through 90° until 1890, but its change is slow compared with that of the others, and in its relation to B, we need not for the present consider its effect on G.

The above quantities enter A as a sine function with co-efficients about one-twentieth of those for B, but the precession factor appearing in the denominator of *tan* G, makes the changes in numerator and denominator about equal for maximum values of the function. But G being determined by its tangent the magnitude of its changes depends also on the absolute values of B and A, for when B is small a given change in A has very much more influence on the angle. In general we may expect changes in G of less than a degree per day.

When we have very small values for B, as in 1890, and also very small values for A, as in May, a combination of these may give changes in G for five days, amounting to 30° or more; but, as will be shown later, this does not render the method inapplicable. When B has its largest value, G does not change more than, say, 5°, which reduces the product of dg by dG to a quantity less than 0″.10, and when dG is very large dg is small enough to reduce the product considerably under 0″.10, so that in general we may estimate the neglected term to be less than 0″.10. The product of any two of these differences that actually occur together is usually only a few hundredths of a second, so that the method will satisfy all the requirements of the latitude work.

These considerations show that the star's position may be derived with all necessary accuracy by the application of differential quantities, when the difference between the two dates is not more than five days. The following two forms show the reduction by both methods. It will be noticed that the method by differences involves only about half the number of figures used in the logarithmic method, besides requiring very little mental labor:

STAR 289.—*Method by logarithms.*

		α	sin δ	cos δ
	h. m. s.	° ′		
$\alpha^0=$	3 11 40	47 55	9.7453	9.9196
$\delta^0=$	------	33 48		
	$\delta'-\delta$	g cos $(G+\alpha)$	h cos $(H+\alpha)$	i cos. δ $\tau\mu'$
	Jan. 20.	151° 5′	19° 9′	0.5408
		9.9422	9.9753	−3.47
		0.8751	1.0219	
	−0″.45	−7.50	+10.52	
	Jan 25.	148° 59′	14° 15′	0.5995
		9.9330	9.9864	−3.98
		0.8499	1.0301	
	−0″.34	−7.08	+10.72	
		Jan. 20.	Jan. 25.	
	G	103° 10′	101° 4′	
	H	331° 14′	326° 20′	
	log g	0.9329	0.9169	
	log h	1.3013	1.2984	
	log i	0.6212n	0.6799n	

STAR 289.—*Method by differences.*

			α		
		h. m. s.	° ′		
	$\alpha^0=$	3 11 40	47 55		
	$\delta^0=$		33 48		
			(G+α)	(H+α)	
		Jan. 20.	151° 5′	19° 9′	Jan. 25.
		Sin (G+α)	+.483		+.15
		Cos (G+α)	—.875	— 7.50	+.27
		Sin (H+α)	+.328		+.56
		Cos (H+α)	+.945	+10.51	—.12
		Sin δ	+.556		+.24
		Cos δ	+.831	— 3.47	—.51
				— 0.46	+.15
Jan. 20.			Jan. 25.		
G 103° 10′		$dG=$	— .0367		
H 331° 14′		$dH=$	— .0855		
g + 8.57		$dg=$	— .31		
h +20.01		$dh=$	— .13		
i — 4.18		$di=$	— .61		
		$-gdG=$	+ .314		
		$-hdH=$	+1.71		

Explanation of computation.

In both methods the quantities below the double lines are the same for all stars, varying only with the date, and are therefore written but once. The first computation is the usual logarithmic one and needs no explanation. The second is by Crelle's tables and differences. In the first column are the natural trigonometric functions. In the second are the quantities g cos (G + α), h cos (H + α) sin δ, and i cos δ, the sum of which is the reduction to apparent place for January 20. The third column contains the products of the constant multipliers by the corresponding sines and cosines to obtain the following quantities of the differential equations:

$$- gdG \sin (G+\alpha) + dg \cos (G+\alpha)$$
$$[- hdH \sin (H+\alpha) + dh \cos (H+\alpha)] \sin \delta$$
$$di \cos \delta$$

It should be stated that dG and dH are first reduced to linear quantities.

The sum of this last column, omitting the two middle values, gives the quantity to be applied to the reduction for January 20 to obtain that for January 25, and will in most cases be found to be correct within one or two hundreths of a second.

The method of differences is considered to be a saving of about one-half the usual time, besides being very much easier; as many as 30 pairs being computed for two dates in about seven hours by a person familiar with the method. After the computation of the first date the corrections to be applied to these to get those for the second date were found in two hours. But in order to work advantageously, each step is taken up systematically and carried through the entire number of pairs; and often two steps may be carried on simultaneously where the multipliers are simple or the tables kept open two places at once. Care should be taken to avoid using more places than are necessary. For example, in the direct computation for the first date, three figures are sufficient except where h enters. It is not considered essential to secure exactly the fourth place here, but it may be done with Crelle's tables mentally and with very little labor by taking the nearest unit in the third place and applying to the product the algebraic sum of the units place by the thousandths—one, or two places at most, being considered.

In forming the products for the differences two places only need generally be retained.

The difference of $0''.03$ between that calculated rigorously for January 25 and that derived by the formulæ is due to the fact that the differences have been treated as differentials and not as finite differences. The neglected product dh, $d\text{H}$, sin $(\text{H} + \alpha)$ does not amount to more than 0.003, and need not be regarded even when sin δ is as much as 0.90, for, as a rule, stars are not observed above 65° declination.

If we had treated the difference in the cosine of $(\text{H}+\alpha)$ as a finite difference, using the formula $-2 \sin(\text{X} + \frac{1}{2}\Delta\text{X}) \sin \frac{1}{2}\Delta\text{X}$ instead of $-\sin \text{X}d\text{X}$, the agreement would of course have been perfect; the essential points in the method being that the differences are considered as differentials and the term involving the product of the differences is neglected.

It might be supposed that if we have a difference of $0''.03$ in the position of a star for a difference in H of, say, 5° that this discrepancy would amount to a quantity entirely inadmissible in the case of G in May, 1890, where the difference is upwards of 30°; but since the tan of G varies directly as B, and since when these excessive changes in G occur, B is necessarily quite small because the longitude of the moon's ascending node is near 90°, the discrepancy between the values of $g \cos(\text{G} + \alpha)$ calculated by the differential formulæ and those by actual multiplication does not much exceed that in the present case, in fact, they only differ by $0''.05$. Indeed, the large discrepancy in the present case is due to the fact that the error committed in neglecting the formula for finite differences must be multiplied by h, which increases it twenty fold; g in the extreme case of 1890 is 0.8, hence only one twenty-fifth of h for this case. But the discrepancy for the values of May, 1890 comes from another source, viz, from the product of the two differentials dg and $d\text{G}$ and even then will only occur for a few pairs where $(\text{G} + \alpha)$ is near 90°, and hence the sine is large. It will be noticed that assuming a value for $(\text{G} + \alpha)$ which gives the most rapid change in the cosine also gives a large value for the sine and hence increases the value of the term $dg \sin(\text{G}+\alpha)\, d\text{G}$; and that there is a combination of circumstances tending to increase our discrepancy to $0''.08$.

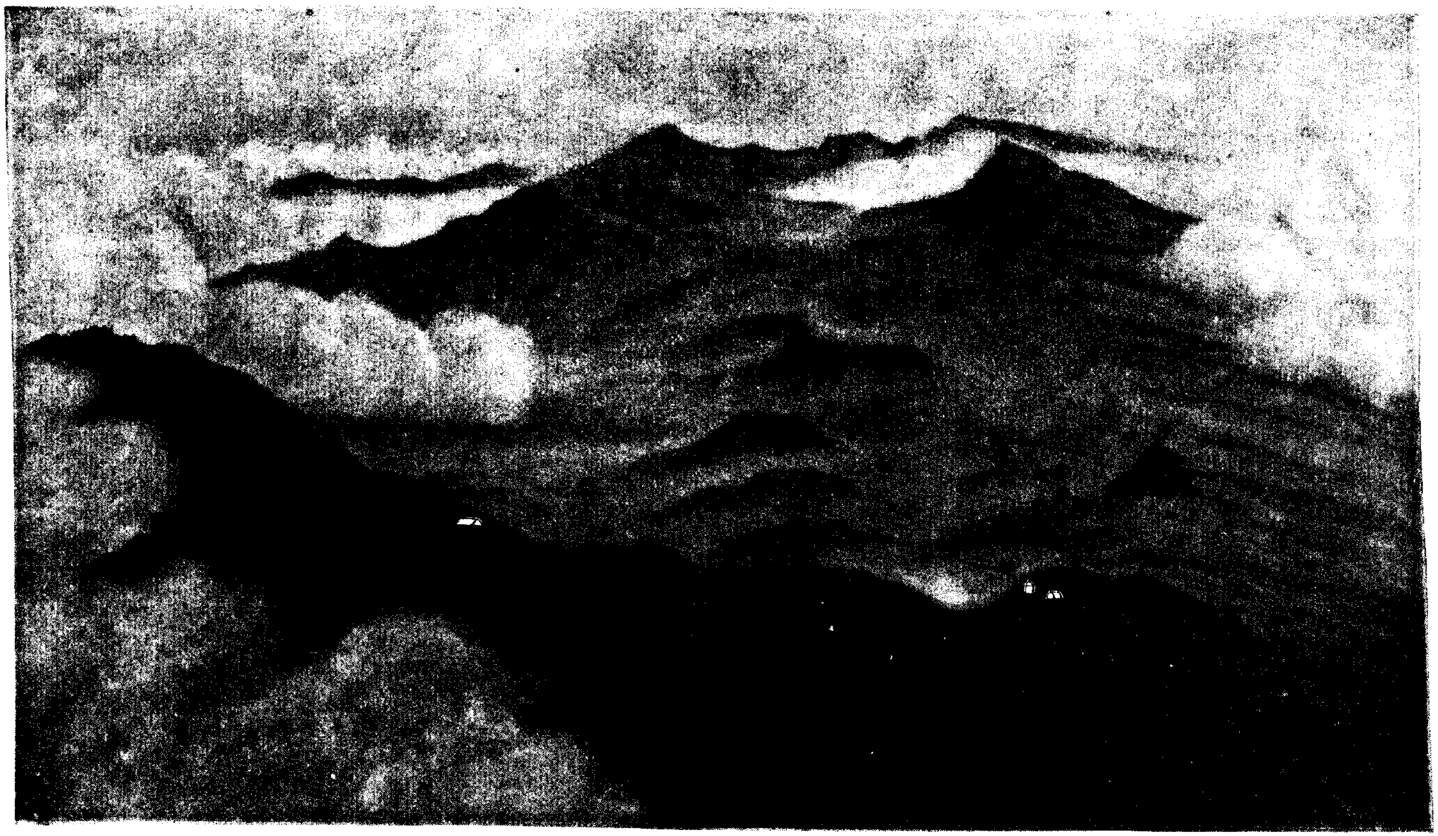
This may readily be neglected when we consider that the probable errors of the declinations of the individual stars are several times as large.

In general the errors introduced by this method are quite insignificant, even admitting the declinations to be absolutely true. Besides, for the extreme case of 1890 we have assumed a value for $(\text{G}+\alpha)$ which would give the greatest possible change in the cosine for the change in G under consideration, viz, a value extending from about 85° to 105°. Moreover, since this term depends on the star's right ascension, for any station this extreme case would only apply to a few pairs which involved values of $(\text{G}+\alpha)$ passing through the points 90° or 270°, no night's work ever lasting long enough to pass through or even near them both.

When the observations do not extend beyond five days the last date is derived from the first by differences. For work extending over a period of from five to fifteen days, the middle date is actually computed and the first and last computed by differences. Where on account of bad weather, observations are very much scattered, it is better to make separate computations for each date. Under ordinary circumstances, three successive nights are all that are required, which involve differences in the star numbers for only two days; in this case the result by differences will be found to be identical with those of a rigorous calculation. For where $d\text{G}$ and $d\text{H}$ are about 2° and dg and dh one or two tenths, their product does not affect the hundredths place, and the change in the cosine of an arc, whether computed as a differential or a finite difference, is practically the same for differences of arc of 2°, the discrepancy never amounting to a unit in the hundredth place.

Assuming the probable error of observation to be 0″.50, which is about the usual experience, and the probable error of one declination to be 0″.30, we find the following relation between the number of nights, number of pairs, and the probable error of the mean result:

Number of nights.	Number of pairs.					
	5	10	15	20	25	30
	Resulting probable error of mean result.					
	″	″	″	″	″	″
3	0.17	0.12	0.09	0.08	0.07	0.07
5	.15	.10	.08	.07	.06	.06
7	.13	.09	.07	.06	.06	.05



Anamoehaole.
(9,300 feet.)

Pakaoao.
(10,000 feet.)

CRATER OF HALEAKALA—LOOKING TOWARDS KAUPO GAP FROM VICINITY OF PAKAOAO.

APPENDIX No. 14.—1888.

DETERMINATIONS OF LATITUDE AND GRAVITY FOR THE HAWAIIAN GOVERNMENT.

By E. D. PRESTON, Assistant.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, July 8, 1889.

DEAR SIR: I have the honor to transmit you to-day my report on the observations and computations made for the Hawaiian Government.

This report is somewhat fuller in illustration and in detail than would have been necessary, had it been made on work done in this country and written only to appear in the annual Coast and Geodetic Survey Report, several sketches and one or two forms of computation being introduced which have already appeared in our Reports, but which it was thought best to give, inasmuch as many persons who will read the report have not access to the Coast Survey publications.

In a letter recently received from Surveyor-General Alexander, he says they look with great interest for the appearance of the report.

The results are, moreover, of general scientific interest. Professor Dana says (American Journal of Science, February, 1889, page 87): "They afford unexpected evidence on these doubtful points" (density of volcanic mountains).

The addition of relative forces of gravity at eight new stations to the data already existing furnishes considerable matter bearing on the determination of the earth's figure, especially as these stations have a range of about 50 degrees in latitude and 10,000 feet in elevation.

The lengths of the Peirce pendulums are published here for the first time.

In view of the above statements I beg leave to ask you whether this report could not be made special and published immediately. The Hawaiian Survey could then have their copies without delay.

I remain, very respectfully, your obedient servant,

E. D. PRESTON,
Assistant.

To the SUPERINTENDENT OF THE
COAST AND GEODETIC SURVEY,
Washington, D. C.

NOTE ON HAWAIIAN PRONUNCIATION.

As some native words necessarily appear in this report, in order to aid those readers who may not be familiar with the Polynesian languages the following remarks are made: Two invāriable rules lie at the foundation of Hawaiian pronunciation; every word must end with a vowel and no two consonants are pronounced without an intervening vowel. When the missionaries reduced the language to writing, about 1820, they adopted the Latin pronunciation. Each character represents but one sound, so that the language is entirely phonographic. The vowels are then to have the sounds given them in the Romance languages (except u, which has the sound given it in Spanish and Italian, and not that of the French), and the consonants are in general close approximations to the corresponding ones in those languages. A few exceptions exist, arising from the inability of the early Hawaiians to distinguish between t and k and l and r. The word for star is pronounced indifferently "hoku" or "hotu," and the French travelers, in 1819, wrote Onorourou for Honolulu. As the missionaries found only two words in the language having the sound of d, viz, "hido" and "lido," this sound in those words is replaced by the sound of l in the Hawaiian of to-day. Although two consonants may not appear together, any number of vowels are allowable, as, for example, in the words Pakaoao and Hooiaioia, and in the sentence "E ae au ia oe." The accent is generally on the penult, as in Honolulu, Kohala, Kahuku, etc.

REPORT.

The latitude and gravity observations made for the Hawaiian Government during the year 1887, may be said to have had their origin in the determination of a latitude on the island of Maui in 1883. Two members of the United States Solar Eclipse Expedition stopping here on their way home, in order to determine the force of gravity at De Freycinet's station of 1819, furnished the Government Survey with a value of the latitude of Lahaina which differed 15″ from that derived from Honolulu, and based on the English observations of 1874. In order to test the astronomical observations at the two extremities of the triangulation, Prof. W. D. Alexander, the Surveyor-General of the islands, at once conceived the project of having a number of latitudes of precision determined, which should not only include Maui, but all the larger islands. Owing, however, to lack of appropriations, this plan could not be immediately realized, and it was not until 1886 that a formal request was made by the Hawaiian Government for the loan of the necessary instruments, and the detail of an observer to execute the work.

The following letter states the conditions under which the work was undertaken:

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, D. C., December 10, 1886.

SIR: In pursuance of the request of the Hawaiian Government, communicated through the Hon. H. A. P. Carter, Hawaiian minister, and of your own letter of this date, and under authority of the Treasury Department contained in letter of December 9, you are hereby granted a leave of absence, without pay, from December 15, 1886, for six months or such portion thereof as may be necessary, for the purpose of making certain astronomical and geodetic observations, and probably some gravity experiments at the expense and under the direction of the Hawaiian Government.

The necessary instruments and accessories for this work will be supplied by the Coast and Geodetic Survey and will be held at the risk of the Hawaiian Government. It is understood that copies of all the observations made will be furnished for the use of this office.

Yours, respectfully,

F. M. THORN,
Superintendent.

E. D. PRESTON,
Subassistant Coast and Geodetic Survey, Washington, D. C.

The scheme proposed by Professor Alexander contemplated the occupation of fourteen latitude stations, of which three were on Kauai, three on Oahu, four on Maui, and four on Hawaii. But as the object of the observations was the determination of the deflections of the plumb-line, and as this depends on the density of the mountains, it was thought advisable to supplement the latitude work by some measurements of the force of gravity. Therefore the original plan was extended so as to include pendulum observations on the summit of Haleakala, Maui, at a station near the sea-level of the same island and at Honolulu. This last station was also occupied in 1883, which gives a connection between De Freycinet's station and all the stations of 1887.

In view of the general scientific interest in the question of plumb-line deflections, the Hawaiian Government was led to ask, through the Honorable H. A. P. Carter, Envoy Extraordinary and Minister Plenipotentiary at Washington, that the observations might be reduced and discussed according to modern methods by the Coast and Geodetic Survey. The matter was taken up immediately, and the computations begun on January 1, 1888. In addition to these reductions, the length and position of the center of mass for each pendulum has been determined, a bulletin* has been published giving some preliminary results of the work, and some original investigations made for the sake of shortening the methods of reduction.

To this report are also appended the results of pendulum observations at three continental stations occupied in 1887, and three island stations occupied in 1883. The former being all in the same journey, and the latter being occupied by one of the same observers and using the same instrument, and the two journeys having two stations in common, they naturally fall in the same series and should appear together.

Professor Alexander was present at Puuloa and on the summit of Haleakala. Messrs. F. S. Dodge and W. A. Wall, of the Government Survey, took part in the pendulum observations at the three island stations, and Mr. Wall was with the party during the entire season and recorded the latitudes. Mr. Dodge recorded part of the observations at Kahuku, and Mr. J. S. Emerson part of those at Ka Lae. All the time and latitude, and one-half the pendulum observations, were made by myself. At San Francisco I was assisted by Mr. C. B. Hill; at the Lick Observatory by Mr. J. E. Keeler, and at Washington by Mr. J. B. Baylor. My thanks are due to all these gentlemen, as well as to Professor Davidson, Prof. E. S. Holden, and to the trustees of the Lick Observatory for interest in the work and for facilities given for its successful execution.

In the work of 1883 Prof. S. J. Brown, U. S. Navy, one of the members of the eclipse expedition, assisted in the observations at Caroline Island, at Lahaina, and at Honolulu. Mr. C. B. Hill took Professor Brown's place at San Francisco.

INSTRUMENTS.

The following was the instrumental outfit:

Davidson meridian telescope, Coast and Geodetic Survey No. 1; sidereal break-circuit chronometer, Frod. 3479; sidereal break circuit chronometer, Hutton 221, yard pendulum, Peirce No. 3; metre pendulum, Peirce No. 4; pendulum head, Peirce No. 0; sidereal chronometer watch, Jurgensen 7932; mercurial barometer, Green 2016; amplitude scale; aneroid barometer (Pitkin); chronograph, Fauth No. 5; reading telescope; condensing lens (5-inch diameter); Baudin thermometers, 9242, 9243, 9248, 9252; switch board; brass temperature tube; gravity battery (3 cells); extra levels (2); electrical connections, insulated wire, observing key, lamps, mirrors, and other necessary accessories.

Most of this list was supplied by the San Francisco sub-office. The pendulums, thermometers, and watch were furnished from Washington.

The meridian telescope has an aperture of $2\frac{1}{4}$ inches; focal length, $31\frac{1}{2}$ inches; magnifying power 60 was used; one revolution of eye-piece micrometer$=64''.35$; one division of latitude level$=0''.92$; one division of striding level$=1''.05$, and one division of azimuth micrometer$=1''.66$.

The yard and metre pendulums are both of the invariable reversible type; the distances of the center of mass from the two knives are as three to one. The times of oscillation in the two positions differ by $0^s.00003$ for pendulum No. 4, and by $0^s.0002$ for pendulum No. 3.

The Frodsham chronometer breaks the circuit at the first second and at every even one. Hutton breaks the first second, every even one, and the half second immediately preceding the even one.

One division of the amplitude scale is equal to 0.050 inch. The distances from the point of support to the end of the pendulums are, for pendulum No. 3, 46.44 inches; pendulum No. 4, 1.291 metres. Hence in the former case one division is equal to .00108 R, and in the latter to .00098 R.

On December 15, 1886, a leave of absence without pay for six months was granted me. Leaving Washington on this date I arrived in Honolulu on the 12th of January, having stopped in San Francisco long enough to test and pack the instruments. Nine days later the first observations were made at Puuloa. The Government placed at our disposition the steam-tug *Pélé*, which transported the party and instruments to Pearl Harbor. Arriving at 4.30 p. m., January 21, observa-

* No. 11.

tions were made for time and micrometer value the same evening, and for latitude on January 24, 25, and 26. The last night's work was done with difficulty on account of smoke and dust from Mauna Loa, which was in eruption at the time. The second station was at Kahuku, at the extreme northern point of Oahu. The instruments were shipped by schooner from Honolulu on February 1, the party leaving the following day on horseback and going by the way of Waialua. Observations were completed here on February 12. Circumstances were unfavorable at this station. Clouds and rain prolonged very much the time of observing. On February 9, work lasted from 6.30 p. m. to 4 a. m., with only thirty-three pairs observed. On the 11th, three hours observations gave no more than two pairs. The observing station was situated a mile from our lodging place. At midnight of the 12th, the requisite number of measures being made, the instruments were dismounted and packed, and on Sunday, the 13th, the party rode to Honolulu, a distance of 44 miles, climbing the Pali, a mountain pass 1,200 feet high.

Between February 13 and 22 the time was spent in Honolulu duplicating records, making computations, and preparing the station for gravity measurements. Taking the steamer *Mikahala* on the evening of the 22d, we arrived at Waimea, on the island of Kauai, at noon of the 24th. The pier was constructed in the afternoon (thanks to the energy of Mr. L. H. Stoltz) and observations for time and azimuth were made in the evening. The latitude and micrometer determinations were concluded on March 4, and on the 5th the party and instruments were transferred to Koloa. The transportation of the instruments was a matter of difficulty. An ox-cart of the most primitive kind was the only vehicle available, and the road was in a very bad, not to say dangerous, condition for the transportation of instruments of precision. To guard against possible accident the object glass of the telescope, the eye-piece micrometer, and the levels were removed and packed in a separate box surrounded by cotton. Arriving at Koloa at noon, the instruments were put together, adjusted, and mounted before sundown, and observations were made in the evening. The work was finished on March 16, and on the following day everything was shipped to Hanalei by way of Honolulu. On the 19th the party rode to Kapaa, passing the falls of Waieleele, the road leading through valleys whose sides were covered with guava, cocoa-nut, bread-fruit, fig, and mango trees. The recent rains had swollen the mountain streams and the horses were once obliged to swim, which resulted in a complete wetting of saddle-bags, clothing, and records. From Kapaa to Hanalei consumed the greater part of a day, and we arrived on the evening of March 20, after six hours' travel through a pouring rain. Observations ended on the 31st, and Honolulu was reached on the morning of April 3. This place was occupied for latitude before April 12, besides making duplicates of records and some minor computations.

It was now seen that the six months originally allotted to the work would not suffice. I therefore, at the request of the Surveyor-General, asked for an extension of furlough for three months, to enable us to complete the whole programme. This was granted in a letter from Washington dated April 27, and fixed the time of my return not later than September 15.

On April 12 we took the steamer *Kinau* for Mahukona, Hawaii, arriving on the 13th. Kohala was reached at noon. The pier was constructed on the 15th. In the evening the instrument was put in position, the chronometer correction determined, and thirty-three pairs obtained before midnight. The last observations were made on the 17th and the instruments repacked the following day. On account of the violent wind nearly always prevailing at this point, it was found impossible to pitch a tent for shelter; refuge was taken in an old building formerly used for storing sugar. Leaving Kohala at daybreak of the 19th the harbor of Hilo was reached at midnight.

The rain-fall here is exceptionally large, even for the tropics, as much as 20 feet having been measured in one year. The instruments were mounted on the summit of Halai, and were in position by the evening of the 21st. But only one clear night was experienced during our three weeks' stay. Some one of the party was always standing watch throughout the entire night, so that any partial break in the clouds might be utilized. Thus availing ourselves of every possible occasion, by May 14 about forty pairs had been observed, giving between sixty and seventy independent measures. More observations were desired, but it was not considered advisable to prolong the occupation until the return trip of the steamer. The station was abandoned, therefore, on Saturday, May 14, and on the 15th horses were engaged and the party left for Ka Lae, a distance of about 85 miles. The crater of Kilauea was visited on the 17th and found to be in eruption at two

Resting at "Ana moe haole" (9,300 Feet Elevation). Edge of Crater.

points, although the old lake of 1883 had entirely subsided and disappeared. Passing by Punaluu, Waiohinu, and Kaalualu, Ka Lae was reached at noon of the 21st.

The nearest water suply was eight miles distant. It was brought on mule back; part of the road leading over an "aa" lava flow. The animals could only be sent to drink every two days. The last observations were made on the morning of the 28th, and we were again in Honolulu at 4 p. m. of the 31st. This station was now occupied for gravity, pendulums Nos. 3 and 4 being swung on three days and nights each.

On June 14, the party left for Kailua, Hawaii. This station was finished on the 19th, and on the following day we started for Haiku, via Maalaea Bay, arriving on the 21st. Haiku lies at the base of Haleakala and was occupied for latitude and gravity. The pendulum was started on June 23, and the last star observations were made at 10 p. m. of June 29. At 11 a. m. of the 30th, the ascent of the mountain was begun. The party now consisted of eighteen persons and twenty-five animals besides a cart drawn by twelve oxen. At 5 o'clock Olinda was reached. This lies near the lower limit of the cloud region (4,043 feet) and we encountered heavy fog and rain. A stop was made for the night.

On the morning of July 1, the journey was resumed. After three hours' travel a point was reached beyond which it was impossible to take the cart. The instruments, tents, and provisions were now packed on mules to be carried to the summit, the chronometers, barometers, and thermometers being taken in the hand. Passing through the cloud belt at an elevation of 8,000 feet we met clear weather again and arrived at Ana moe haole, the northwest edge of the crater at 3 p. m. The elevation at this point is considerably over 9,000 feet, and the animals were suffering from the rarity of the atmosphere and from travel over the lava. A rest was taken for an hour (see illustration No. 41), then the route was continued along the edge ot the crater, a distance of 3 miles, to Pakaoao, at an elevation of 9,870 feet, the point chosen for the observations.

Before making the ascent it was thought feasible either to make a cavity in the ground in which to swing the pendulum, or to build a small stone house, using the somewhat regular blocks of lava which were said to be in abundance on the summit. Both these projects were soon seen to be impracticable. Fortunately a crevice about 3½ feet wide and 9 feet high was found between two large rocks that possessed the requisite stability and gave promise of quite uniform temperature. This crevice was closed behind by masonry laid in cement, and in front partly by blankets and tarpaulins and partly by masonry (see illustration No. 42), thus permitting ingress and egress in order to start the pendulum and turn it when necessary. Above, dry masonry covered with blankets and a layer of sand was used. The daily range of temperature outside the house and in observing tent was about 30° Fahr. Inside the pendulum house it was 11° centigrade. Although in the tropics and in midsummer, ice was formed nearly every night, the greatest thickness being about one-fourth of an inch. The atmosphere was exceptionally clear—many stars were observed before sundown with a telescope of 2½-inch aperture and magnifying power of sixty. All lava found on one of the peaks is highly magnetic, and differences of several degrees in the declination of the needle within a distance of 2 miles have been noticed on the floor of the crater.

As no provender or water are to be found on the summit, all the animals and all men not necsary were sent down the slope on July 2 to a point where these were to be had.

The first observations were made on July 4; the last on the 12th. The weather was good on the summit, the storms generally occurring several thousand feet below.

Leaving Pakaoao at 8 a. m. of the 13th the party divided, the greater number returning by the way of Olinda and Makawao, and taking the instruments. Mr. Wall and myself with a guide passed down into the crater (see illustrations No. 39 and 43) 2,600 feet below, and out the Kaupo Gap, reaching Kipahulu at 7 p. m. We arrived at Hana on the 15th and closed the work there on the 26th. The weather was very unfavorable. Hana in this respect is a worthy rival of Hilo, and although the rain-fall is much less, the nights are generally cloudy. The difficulty in securing pairs of stars may be judged from the fact that one night's work of eleven hours only gave as many pairs. Arriving at Ka Lae o Ka Ilio on the 28th, the last observations were made on August 1. Seventy-five pairs were observed at this station in seven consecutive hours.

The night's list contained more than one hundred pairs. Generally, it may be said of all the stations that lists covering from eight to ten hours' right ascension, and having about one hundred pairs, were selected in order to be ready for clear weather at any part of the night. These extended lists, however, were only utilized at a few of the windward stations. The work at Kaupo closed the observations for the season, and we took the steamer for Honolulu, arriving there on the 6th. During the remainder of August we were engaged in the Government Office making duplicates, reading chronographic sheets, and making preliminary computations. A transit instrument belonging to the Government Survey was also adjusted and mounted in the new observatory. On the 30th at noon, my connection with the Hawaiian Goverment ceased and I sailed for San Francisco, arriving at 2 p. m. of September 6. The following day, work was resumed on the Coast and Geodetic Survey, preparations being made for the determination of gravity at Lafayette Park Astronomical Station. Observations were begun on September 12 and finished on the 22d. Lick Observatory was the next station to be occupied. On account of the preparations then being made for the formal transfer of the observatory from the Lick trustees to the State, it was impracticable to make the pendulum observations immediately; and it was not until Sunday, October 9, that I left for Mount Hamilton. The intervening time was devoted to reading the chronograph sheets for San Francisco, and doing miscellaneous office work. The operations at Mount Hamilton lasted from October 13 to 26. On the 30th (Sunday) I arrived in San Francisco. That part of the instrumental outfit which was obtained here ten months previously was returned to the Suboffice, and on November 3 I left for Washington, arriving on the evening of the 9th. The instruments shipped by freight from San Francisco on November 1 arrived in Washington on December 7. The Smithsonian Institution (our base station) was occupied between December 8 and December 18. Duplicating records, reading chronograph sheets, and computations consumed the time until January 1, 1888, when the reduction of the whole work, fourteen latitude and six gravity stations, was begun.

TRIANGULATION.

The trigonometrical connections were executed by the Government Survey, and the geodetic latitudes, computations relating thereto, and the sketches of the triangulation were furnished by Professor Alexander. The following extract from the Hawaiian Survey report for 1872 refers to the base measurement on Maui and the angle measurements for the primary triangles connecting the islands:

* * * At the same time they (the U. S. Coast Survey) sent us a complete set of apparatus used in measuring subsidiary base-lines. * * * A base-line was chosen 4¼ miles in length, crossing the isthmus of Maui nearly at a right angle, the northern end being 7 feet and the southern 164 feet above mean tide. After grading and clearing the line, and making a preliminary measurement with a long wire, the final measurement with the rods was commenced August 18, 1871 and finished September 8. The mean temperature of the bars during the whole measurement was 94° Fahr. The final corrected length of the line is 6,667.79 metres and the probable error of the measurement is believed not to exceed an inch. * * * The true bearing of the line was determined by a long series of observations at the South Base on the Pole star and a lantern set on the North Base, the exact time being noted by a chronometer. * * * The angles of the primary triangles were measured with a transit theodolite made by Troughton & Simms of London, with a horizontal 12-inch circle reading to one second by two micrometer microscopes, and a vertical 12-inch circle reading to five seconds by two verniers. It is completely fitted for night observations on stars. The telescope has generally been used with a magnifying power of 36, and is remarkably clear. The closing error of the first quadrilateral was one second.

CONNECTIONS BETWEEN THE TRIGONOMETRICAL AND ASTRONOMICAL STATIONS, AND GEODETIC LATITUDES OF THE LATTER

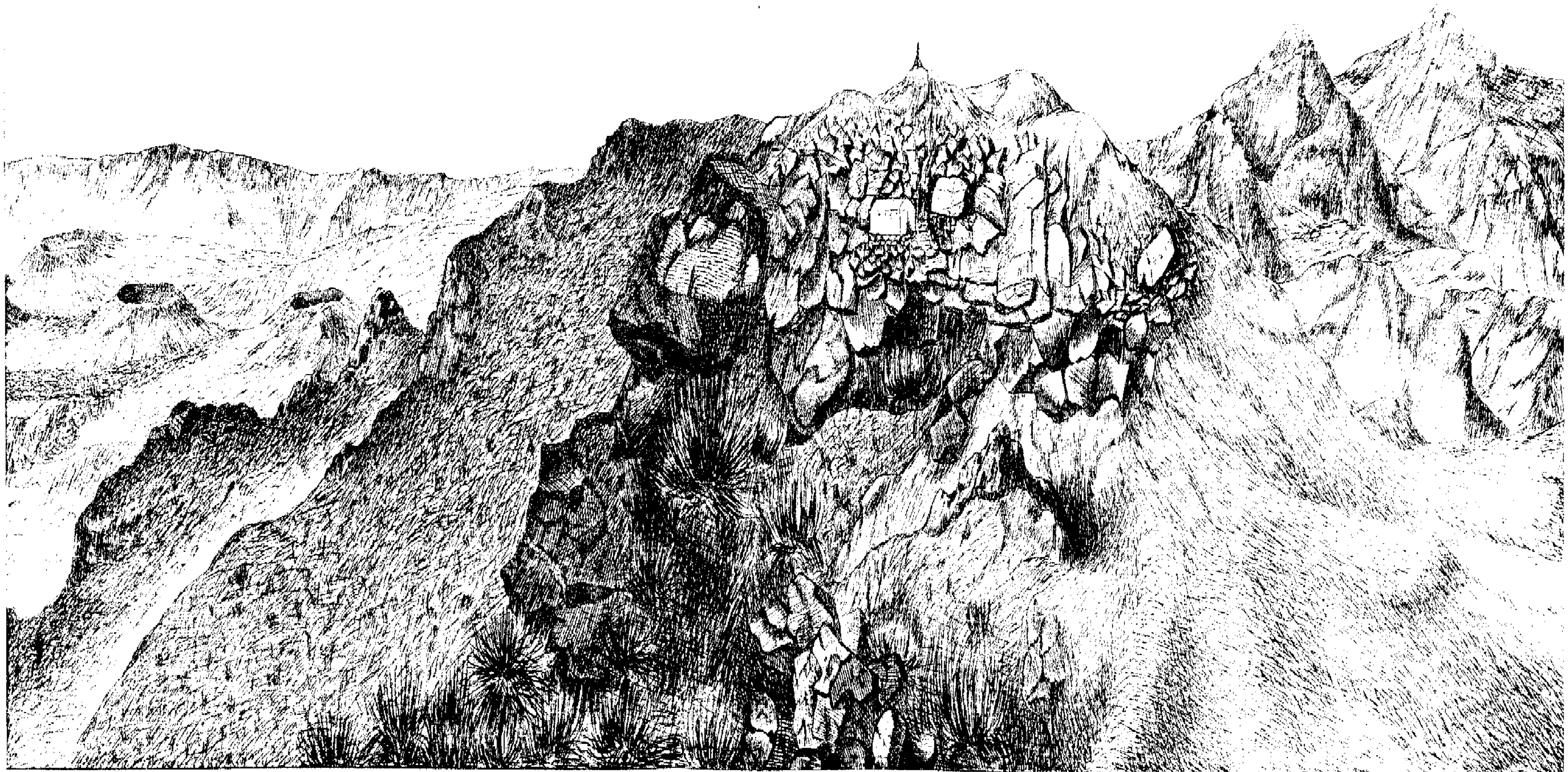
Kauai.

Of this island only a preliminary triangulation exists. It was made with a small instrument and the latitudes on which it was based are only approximative. The geodetic latitudes are derived from Lieutenant Welling's latitude of the Waimea transit of Venus station, given as 21° 57′ 12″.

Waimea:

$\varphi = 21° 57' 12''$. Astronomical station is 11.8 feet due east of transit of Venus pier.

End of Cart Road (5,500 Feet Elevation), Slope of Haleakala.



Gravity and Latitude Station, Pakaoao, on the summit of the Island of Maui, elev. 10032 feet.
Showing observatory, trig. station, pendulum house, mess tent, Magnetic and Kolekole Peaks.

TRAIL FROM PAKAOAO TO KAUPO GAP.

Koloa:

$\varphi = 21° 52' 40''$. Astronomical and trigonometrical stations identical.

Hanalei:

$\varphi = 22° 12' 10''$. Astronomical and trigonometrical stations identical.

Oahu.

The Oahu latitudes are based on Major Tupman's determination of the latitude of the Transit of Venus station in 1874, which is given as $21° 17' 57''.00$.

Puuloa:

$\varphi = 21° 19' 12''.22$. From trigonometrical to astronomical station is 47.2 feet; azimuth is $175° 1'$, counting from south around by west.

Kahuku:

$\varphi = 21° 42' 16''.08$. From trigonometrical to astronomical station is 333.6 feet; azimuth $2° 0'$.

Honolulu:

$\varphi = 21° 18' 2''.32$. Astronomical station 537.0 feet north and 310.4 east of Transit of Venus pier.

Maui.

The Maui latitudes are based on observations made at North Base by W. D. Alexander in 1872, the latitude adopted for north base being $20° 54' 20''$.

Haiku:

$\varphi = 20° 56' 3''.98$. Trigonometrical to astronomical station = 2,185.4 feet; azimuth is $160° 4'$.

Pakaoao (Haleakala):

$\varphi = 20° 43' 21''.73$. Trigonometrical to astronomical station, 71.8 feet; azimuth, $145° 12'$.

Kaupo (Ka Lae o ka Ilio):

$\varphi = 20° 37' 41''.02$. Trigonometrical to astronomical station, 384.8 feet; azimuth, $140° 40'$.

Hana (Kauiki):

$\varphi = 20° 45' 47''.47$. Trigonometrical and astronomical station identical.

Lahaina (1883):

$\varphi = 20° 52' 53''.19$. Trigonometrical (court-house) to astronomical station, 448.4 feet; azimuth, $146° 18'$.

$\varphi = 20° 52' 7''.47$ (carried from Honolulu).

Hawaii.

The latitudes on this island are provisional, being based on the latitude of Puuloa (Kohala) station, which was carried from Maui by the triangle, Haleakala—Kahoolawe—Puuloa; of which only the angle at Haleakala has yet been accurately measured with the 12 inch transit.

Kohala (Kauhola Pt.):

$\varphi = 20° 15' 17''.71$. Trigonometrical to astronomical station, 14.3 feet; azimuth, $266° 51'$.

Hilo (Halai):

$\varphi = 19° 43' 30''.36$. Trigonometrical to astronomical station, 10.0 feet; azimuth, $51° 37'$.

Ka Lae:

(Not yet connected.)

Kailua:

$\varphi = 19° 39' 3''.78$. North meridian mark of Transit of Venus station of 1874.

Geodetic connection between Honolulu and Kahuku.

FIRST SERIES OF TRIANGLES.

	Station.	Angle.	Distance in metres; logs.	To—
		° ′ ″		
1	East Base,*	74 22 18	3.4734891	West Base.
	West Base.	68 58 53	3.6812399	Puu Ohia.
	Puu Ohia.	36 38 49	3.6676978	East Base.
2	West Base.	85 22 15	3.6812399	Puu Ohia.
	Puu Ohia.	66 49 35	4.0110349	Salt Lake.
	Salt Lake.	27 48 10	3.9759190	West Base.
3	Puu Ohia.	51 47 35	4.0110349	Salt Lake.
	Salt Lake.	23 25 55	3.9209397	Puowaina.
	Puowaina.	104 46 30	3.6251491	Puu Ohia.
4	Salt Lake.	103 29 47	3.9209397	Puowaina.
	Puowaina.	36 53 39	4.1042629	Puuloa.
	Puuloa.	39 36 34	3.8948212	Salt Lake.
5	Salt Lake.	56 43 00	3.8948212	Puuloa.
	Puuloa.	63 28 05	3.8802911	Ewa church.
	Ewa church.	59 48 55	3.9097723	Salt Lake.
6	Puuloa.	39 07 14	3.8802911	Ewa church.
	Honouliuli.	73 25 12	3.8642221	Puuloa.
	Ewa church.	67 27 34	3.6987321	Honouliuli.
6B	Salt Lake.	37 05 24	3.8948212	Puuloa.
	Puuloa.	102 35 16	3.864226	Honouliuli.
	Honouliuli.	40 19 20	4.073292	Salt Lake.
7	Ewa church.	68 47 33	3.6987321	Honouliuli.
	Honouliuli.	88 38 04	4.0841027	Maunauna.
	Maunauna.	22 34 23	4.1144346	Ewa church.
8	Honouliuli.	36 57 46	4.0841027	Maunauna.
	Maunauna.	45 58 52	3.8664928	Waipio Mauka.
	Waipio Mauka.	97 03 22	3.9442002	Honouliuli.
9	Ewa church.	24 59 35	4.1144346	Maunauna.
	Maunauna.	23 24 30	3.8664763	Waipio Mauka.
	Waipio Mauka.	131 35 55	3.8397391	Ewa church.
10	Ewa church.	93 47 07	3.6987321	Honouliuli.
	Honouliuli.	51 40 20	3.9441872	Waipio Mauka.
	Waipio Mauka.	34 32 33	3.8397153	Ewa church.

*Azimuth from West Base to East Base 291° 29′ 35″.

Geodetic connection between Honolulu and Kahuku—Continued.

FIRST SERIES OF TRIANGLES—Continued.

	Station.	Angle.	Distance in metres; logs.	To—
		° ′ ″		
11	Maunauna.	120 05 51	3. 8664846	Waipio Mauka (Av.).
	Waipio Mauka.	27 37 30	4. 0760298	Maili.
	Maili.	32 16 39	3. 8051476	Maunauna.
12	Waipio Mauka.	55 57 38	4. 0760298	Maili.
	Maili.	62 19 44	4. 0496410	Peahinaia.
	Peahinaia.	61 42 38	4. 0785199	Waipio Mauka.
13	Maunauna.	56 53 54	3. 8051476	Maili.
	Maili.	94 36 22	4. 0496368	Peahinaia.
	Peahinaia.	28 29 44	4. 1251419	Maunauna.
14	Waipio Mauka.	83 35 08	3. 8664846	Maunauna.
	Maunauna.	63 11 55	4. 0785117	Peahinaia.
	Peahinaia.	33 12 57	4. 1251397	Waipio Mauka.
15	Maili.	121 40 12	4. 0496368	Peahinaia.
	Peahinaia.	27 20 06	4. 2678341	Mokuleia.
	Mokuleia.	30 59 42	3. 9998552	Maili.
16	Maili.	42 20 12	3. 9998552	Mokuleia.
	Mokuleia.	61 09 48	3. 8403522	Puaena.
	Puaena.	76 30 00	3. 9545269	Maili.
17	Maili.	81 44 10	3. 9998552	Mokuleia.
	Mokuleia.	67 55 45	4. 2219872	Kawela.
	Kawela.	30 20 05	4. 2634687	Maili.
18	Maili.	69 01 27	3. 9998552	Mokuleia.
	Mokuleia.	73 33 53	4. 1865098	Pupukea.
	Pupukea.	37 24 40	4. 1981698	Maili.
19	Maili.	26 41 15	3. 9545269	Puaena.
	Puaena.	125 42 35	3. 9409944	Pupukea.
	Pupukea.	27 36 10	4. 1981757	Maili.
20	Maili.	12 42 43	4. 1981757	Pupukea.
	Pupukea.	117 36 12	3. 6584588	Kawela.
	Kawela.	49 41 05	4. 2634586	Maili.
21	Pupukea.	38 36 19	3. 6584588	Kawela.
	Kawela.	56 01 51	3. 4550330	Waialee.
	Waialee.	85 21 50	3. 5786138	Pupukea.

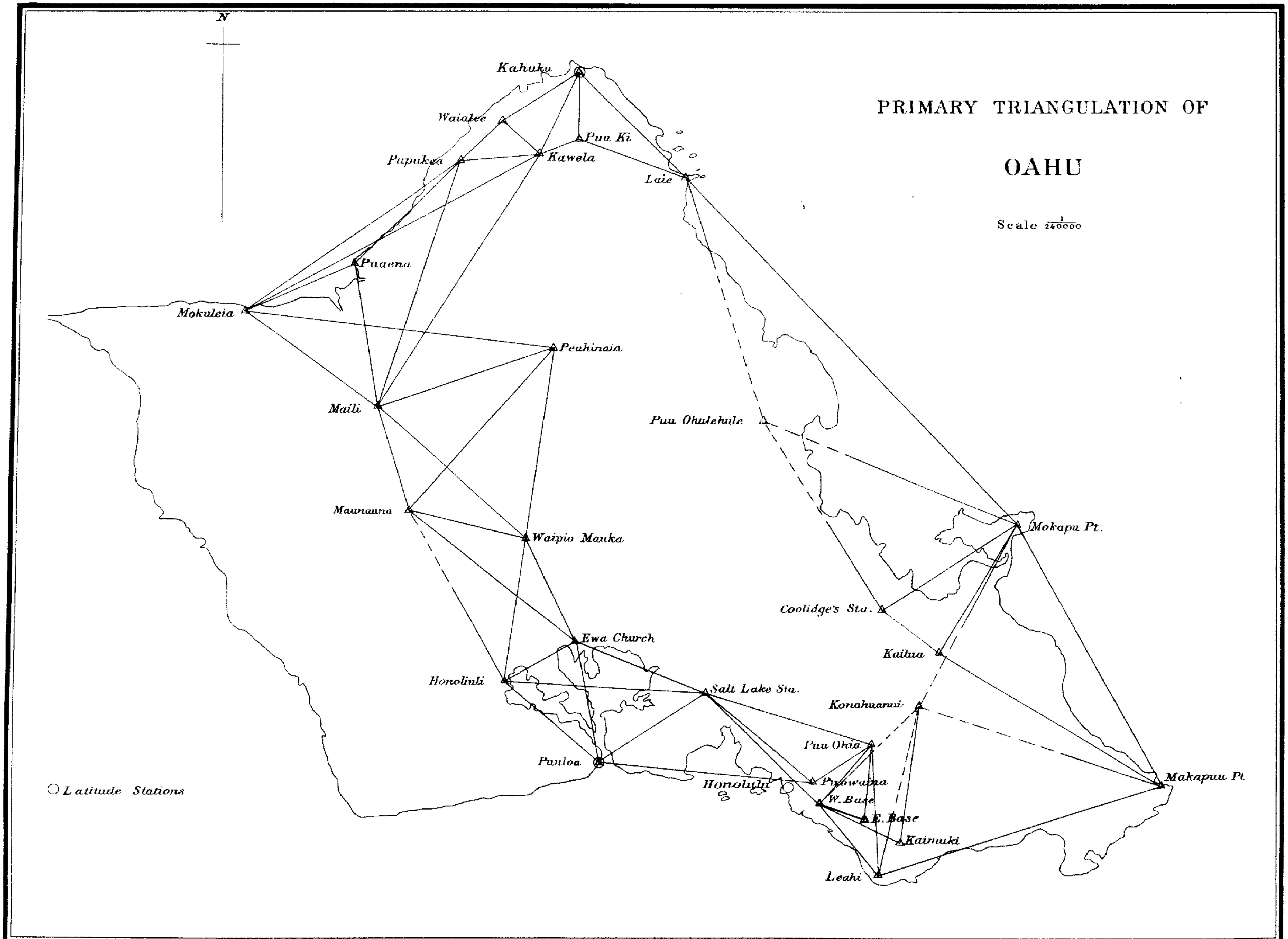
Geodetic connection between Honolulu and Kahuku—Continued.

FIRST SERIES OF TRIANGLES—Continued.

	Station.	Angle.	Distance in metres; logs.	To—
		° ′ ″		
22	Kawela.	67 25 30	3.4550330	Waialee.
	Waialee.	81 48 40	3.7115656	Kahuku.
	Kahuku.	30 45 50	3.7417353	Kawela.
23	Kawela.	46 00 00	3.7417353	Kahuku.
	Kahuku.	23 56 44	3.6258340	Puu Ki.
	Puu Ki.	110 03 16	3.3772851	Kawela.
24	Kahuku.	43 49 56	3.6258340	Puu Ki.
	Puu Ki.	111 03 40	3.8386065	Laie.
	Laie.	25 06 24	3.9681296	Kahuku.

SECOND SERIES OF TRIANGLES.

1	East Base.	74 22 18	3.4734891	West Base.
	West Base.	68 58 53	3.6812399	Puu Ohia.
	Puu Ohia.	36 38 49	3.6676978	East Base.
2	West Base.	99 20 37	3.6812399	Puu Ohia.
	Puu Ohia.	44 46 54	3.9075307	Leahi.
	Leahi.	35 52 29	3.7611551	West Base.
3	West Base.	96 15 41	3.7611551	Leahi.
	Leahi.	51 05 05	4.0266979	Konahuanui.
	Konahuanui.	32 38 14	3.9203320	West Base.
4	West Base.	74 54 29	3.6812399	Puu Ohia.
	Puu Ohia.	57 20 13	3.7966022	Kaimuki.
	Kaimuki.	47 45 18	3.7370851	West Base.
5	West Base.	71 50 33	3.7370851	Kaimuki.
	Kaimuki.	70 05 28	3.9249164	Konahuanui.
	Konahuanui.	38 03 59	3.9203364	West Base.
6	Leahi.	58 55 33	4.0266979	Konahuanui.
	Konahuanui.	83 32 30	4.1746572	Makapuu.
	Makapuu.	37 31 57	4.2391650	Leahi.
7	Konahuanui.	81 36 56	4.1746572	Makapuu.
	Makapuu.	43 38 52	4.2580303	Mokapu.
	Mokapu.	54 44 12	4.1016866	Konahuanui.
8	Makapuu.	29 37 22	4.2580303	Kailua.
	Mokapu.	56 44 38	3.9528837	Coolidge's Station.
	Kailua.	93 38 00	4.1812287	Mokapu.


PRIMARY TRIANGULATION OF
OAHU
Scale $\frac{1}{240000}$
N
Kahuku
Waialee
Puu Ki
Papukea
Kawela
Laie
Puaena
Mokuleia
Peahinaia
Maili
Puu Ohulehule
Maunauna
Waipio Mauka
Mokapu Pt.
Coolidge's Sta.
Ewa Church
Kailua
Honoliuli
Salt Lake Sta.
Konahuanui
Puu Ohia
Puuloa
Puowaina
Honolulu
W. Base
E. Base
Kaimuki
Leahi
Makapuu Pt.
○ Latitude Stations

Geodetic connections between Honolulu and Kahuku—Continued.

SECOND SERIES OF TRIANGLES—Continued.

	Station.	Angle.	Distance in metres; logs.	To—
		° ′ ″		
9	Mokapu.	26 11 27	3.9528837	Kailua.
	Kailua.	85 49 18	3.6305515	Coolidge's Station.
	Coolidge's Station.	67 59 15	3.9846004	Mokapu.
10	Mokapu.	57 26 08	3.9846004	Coolidge's Station.
	Coolidge's Station.	86 06 14	4.1363347	Puu Ohulehule.
	Puu Ohulehule.	36 27 38	4.2096122	Mokapu.
11	Mokapu.	24 38 02	4.2006122	Puu Ohulehule.
	Puu Ohulehule.	129 54 49	4.1963305	Laie.
	Laie.	25 27 09	4.4611861	Mokapu.

The Peaks of Konahuanui and Puu Ohulehule were not occupied with instruments.
Latitude of Laie, first series, 21° 38′ 40″.65; second series, 21° 38′ 40″.53.
Azimuth from Laie to Mokapu, first series, 318° 1′ 24″.6; second series, 318° 1′ 24″.1.

Summary.

Station.	Latitudes.	
	Geodetic.	Astronomic.
	° ′ ″	° ′ ″
Honolulu Observatory.	21 18 2.3	21 18 2.5
Kahuku, trigonometric.	21 42 19.2	----------
Kahuku Observatory.	21 42 16.1	21 43 6.1
Difference.	0 24 13.8	0 25 3.6
Deflection of plumb-line.	----------	0 0 24.9

Geographical positions.

OAHU.

Station.	First series.		Station.	Second series.	
	φ	λ		φ	λ
	° ′ ″	° ′ ″		° ′ ″	° ′ ″
West Base.	21 17 48.16	157 50 55.79	West Base.		
Puu Ohia.	21 19 43.20	49 03.22	Puu Ohia.		
Salt Lake.	21 21 33.62	54 39.17	East Base.	21 17 12.70	157 49 19.75
Puuloa.	21 19 11.76	58 25.64	Konahuanui.	21 20 57.58	157 47 29.44
Honouliuli.	21 21 55.87	158 01 29.45	Leahi.	21 15 20.59	157 48 52.17
Ewa church.	21 23 16.62	157 58 58.89	Makapuu.	21 18 15.75	157 39 20.16
Waipio Mauka.	21 26 38.67	158 00 44.18	Mokapu.	21 27 01.07	157 44 04.68
Maunauna.	21 27 42.86	04 50.23	Coolidge.	21 24 05.61	157 48 42.59
Peahinaia.	21 33 03.30	157 59 37.83	Puu Ohulehule.	21 30 30.59	157 52 41.19
Maili.	21 31 03.81	158 05 45.93	Laie.	21 38 40.53	157 55 16.51
Mokuleia.	21 34 29.10	10 15.33			
Puaena.	21 35 53.45	06 32.14			
Pupukea.	21 39 11.30	02 54.46			
Kawela.	21 39 35.44	00 18.14			
Waialee.	21 40 42.86	01 26.22			
Kahuku.	21 42 19.21	157 58 59.79			
Puuki.	21 40 01.82	59 00.17			
Laie.	21 38 40.65	55 16.57			

Geodetic connection between Haiku and Kaupo.

FIRST SERIES OF TRIANGLES.

	Station.	Angle.	Distance in metres; logs.	To—	Latitudes for Col. I.
		° ′ ″			° ′ ″
1	North Base.*	100 25 07.5	3.8239822	South Base.*	20 54 20.0
	South Base.	59 25 23	4.2794300	Piiholo.	20 51 7.8
	Piiholo.	20 09 29.5	4.2216265	North Base.	20 51 39.8
2	North Base.	29 17 39	4.2216265	Piiholo.	
	Piiholo.	45 11 15	3.9273226	Haiku.	
	Haiku.	105 31 06	4.0886547	North Base.	20 55 43.6
3	South Base.	34 16 21	4.2794294	Piiholo.	
	Piiholo.	103 41 15	4.2041892	White Hill.	
	White Hill.	42 02 24	4.4410687	South Base.	20 43 21.15
4	Piiholo.	25 55 32	4.2041892	White Hill.	
	White Hill.	88 49 20	3.8867102	Hanakauhi.	
	Hanakauhi.	65 15 08	4.2459353	Piiholo.	20 44 37.6

*Azimuth North Base to South Base 27° 35′ 25″.0.

Geodetic connection between Haiku and Kaupo—Continued

FIRST SERIES OF TRIANGLES—Continued.

	Station.	Angle.	Distance in metres; logs.	To—	Latitudes for Col. I.
		° ′ ″			° ′ ″
5	White Hill.	27 22 45	3.8867102	Hanakauhi.	
	Hanekauhi.	82 02 20	3.574786	Haleakala 2.	
	Haleakala 2.	70 34 55	3.907938	White Hill.	20 42 37.2
6	White Hill 2.	18 58 00	3.907938	Haleakala 2.	
	Haleakala 2.	126 00 45	3.661028	Palaha.	
	Palaha.	35 01 15	4.057010	White Hill.	20 44 21.4
7	Haleakala 2.	113 40 00	3.661028	Palaha.	
	Palaha.	46 33 30	4.093537	Ka Lae o Ka Ilio.	
	Ka Lae o Ka Ilio (Kaupo).	19 46 30	3.992672	Haleakala 2.	20 37 38.1

SECOND SERIES OF TRIANGLES.

1	North Base.	80 37 23.5	3.8239821	South Base.	20 54 20.0
	South Base.	76 55 06.5	4.2360637	Puu Pane.	20 51 7.8
	Puu Pane.	22 27 30	4.2304866	North Base.	20 48 47.3
2	North Base.	19 47 43.5	4.2304866	Puu Pane.	
	Puu Pane.	76 45 24	3.7630998	Piiholo.	
	Piiholo.	83 26 52.5	4.2216265	North Base.	20 51 39.8
3	North Base.	29 17 39	4.2216265	Piiholo.	
	Piiholo.	45 11 15	3.9273226	Haiku.	
	Haiku.	105 31 06	4.0886547	North Base.	20 55 43.6
4	South Base.	38 36 50	4.2360637	Puu Pane.	
	Puu Pane.	62 39 17	4.0397505	Puu-o-Kali.	
	Puu-o-Kali.	78 43 53	4.1930553	South Base.	20 44 22.1
5	South Base.	48 18 22	4.2360637	Puu Pane.	
	Puu Pane.	79 05 02	4.2091099	Puu Io.	
	Puu Io.	52 36 36	4.3280282	South Base.	20 40 52.1
6	Puu Pane.	16 25 45	4.2091099	Puu Io.	
	Puu Io.	28 38 58	3.8105550	Puu-o-Kali.	
	Puu-o-Kali.	134 55 17	4.0397726	Puu Pane.	
7	Puu-o-Kali.	36 13 16	3.8105550	Puu Io.	
	Puu Io.	94 35 50	3.7030981	Polipoli.	
	Polipoli.	49 10 54	3.9301788	Puu-o-Kali.	20 40 48.1
8	South Base.	20 01 07	4.3280282	Puu Io.	
	Puu Io.	93 02 20	3.8986264	Puu Olai.	
	Puu Olai.	66 56 33	4.3635763	South Base.	20 38 42.6

Geodetic connection between Haiku and Kaupo—Continued.

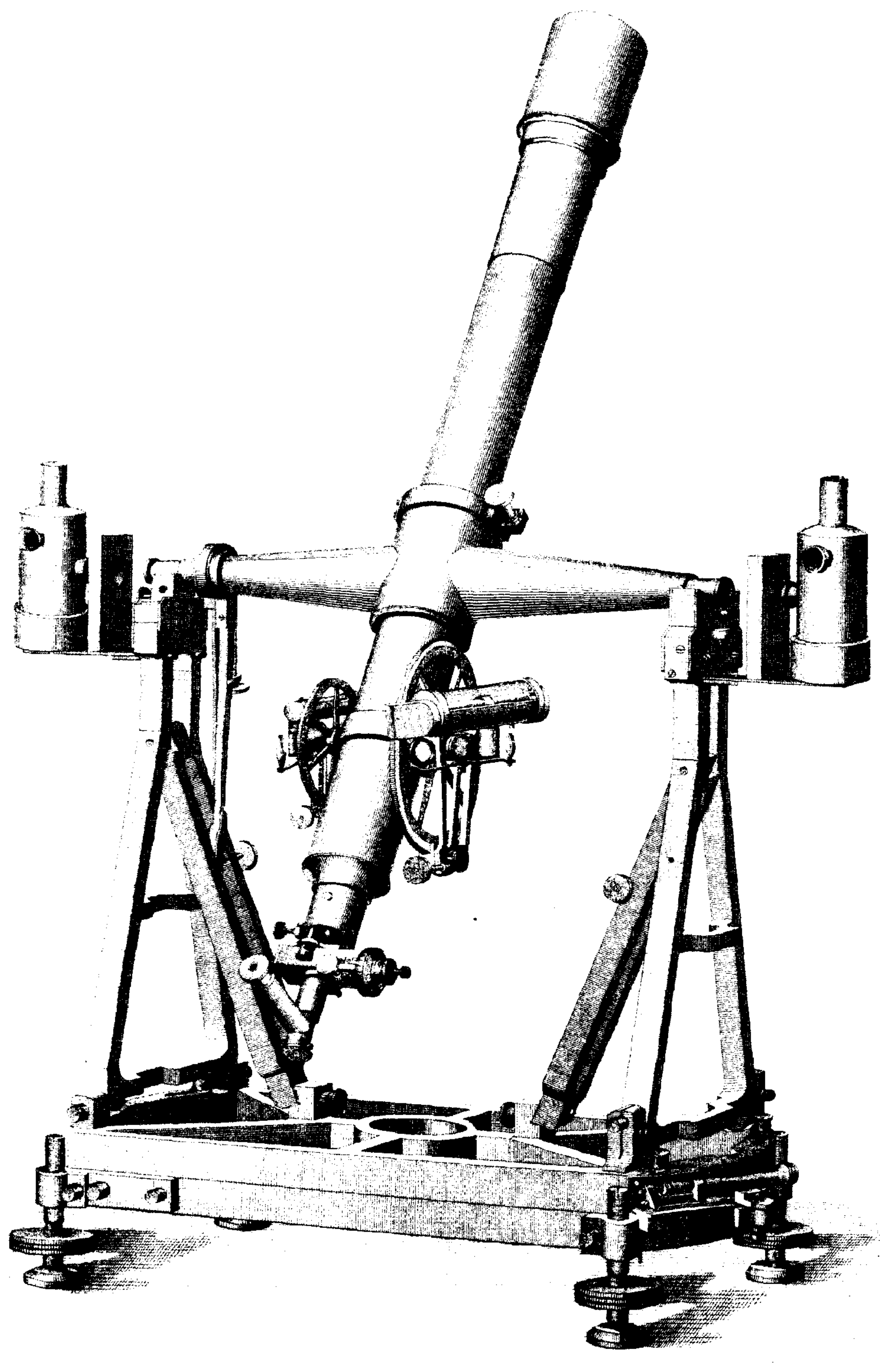
SECOND SERIES OF TRIANGLES—Continued.

	Station.	Angle.	Distance in metres; logs.	To—	Latitudes for Col. I.
		° ′ ″			° ′ ″
9	Puu Io.	148 24 12	3.8986264	Puu Olai.	
	Puu Olai.	12 12 51	4.0969330	Polipoli.	
	Polipoli.	19 22 57	3.7031012	Puu Io.	
10	Puu Olai.	22 12 10	4.0969330	Polipoli.	
	Polipoli.	21 58 00	3.8311961	Puu Mahoe.	
	Puu Mahoe.	135 49 50	3.8267852	Puu Olai.	20 38 26.6
11	Polipoli.	20 34 09	3.8311961	Puu Mahoe.	
	Puu Mahoe.	99 32 42	3.4398912	Pimoe.	
	Pimoe.	59 53 09	3.8881117	Polipoli.	20 37 9.3
12	Polipoli.	53 07 50	3.8881117	Pimoe.	
	Pimoe.	57 58 50	3.8213768	Lualailua.	
	Lualailua.	68 53 20	3.8466126	Polipoli.	20 37 18.8
13	Pimoe.	24 04 45	3.8213768	Lualailua.	
	Lualailua.	103 30 00	3.532937	Shore D.	
	Shore D.	52 25 15	3.910110	Pimoe.	20 35 32.2
14	Lualailua.	112 30 00	3.532937	Shore D.	
	Shore D.	48 12 20	3.979482	Puu Pane 2.	
	Puu Pane 2.	19 17 40	3.886338	Lualailua.	20 39 54.7
15	Shore D.	44 36 35	3.979482	Puu Pane 2.	
	Puu Pane 2.	102 05 00	4.086318	Ka Lae-o-ka Ilio.	
	Ka Lae-o-ka Ilio (Kaupo).	33 18 25	4.230081	Shore D.	20 37 38.1

In the first series, the stations were occupied with the 12-inch transit reading to single seconds, except Hanakauhi, Haleakala 2, and Palaha, which were occupied with 5-inch transits. White Hill is also called Pakaoao, and Palaha is the "Pohaku-oki-aina," *i. e.*, the rock where the boundaries of eight districts meet.

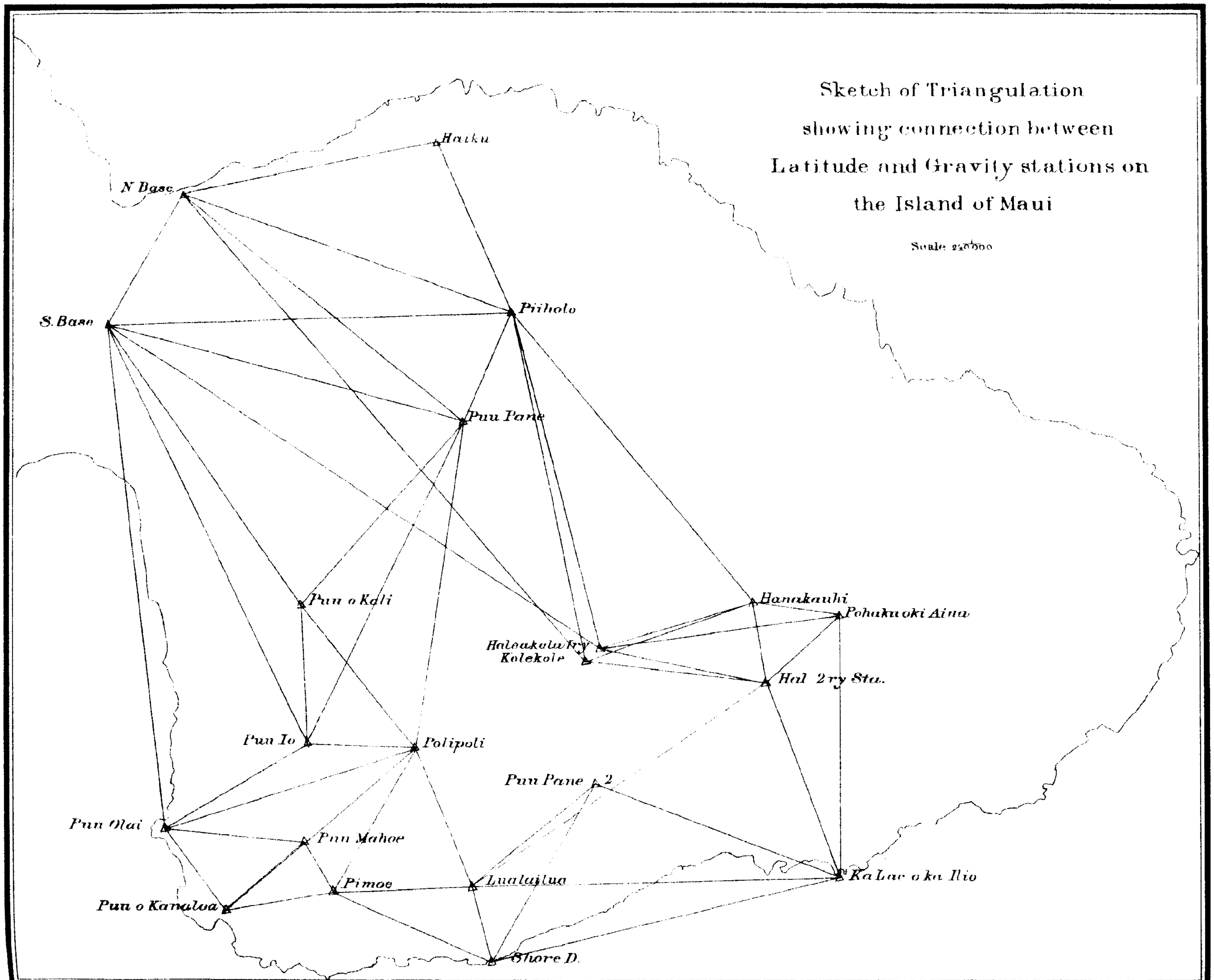
In the second series, the angles of the first ten triangles were measured with the 12-inch transit, except those at Polipoli. The remaining angles of the series were measured with small instruments.

Geodetic latitude of Ka Lae-o ka Ilio, 1st series, 20° 37′ 38″.06; 2d series, 38″.07.



Meridian Telescope.

TRANSIT AND EQUAL ALTITUDE INSTRUMENT


Sketch of Triangulation
showing connection between
Latitude and Gravity stations on
the Island of Maui
Haiku
N Base
S. Base
Piiholo
Puu Pane
Puu o Kali
Haleakala 1ry
Kolekole
Hanakauhi
Pohaku oki Aina
Hal 2ry Sta.
Puu Io
Polipoli
Puu Pane 2
Puu Olai
Puu Mahoe
Pimoe
Lualailua
Puu o Kanaloa
Ka Lae o ka Ilio
Shore D.

Summary.

Station.	Latitudes.	
	Geodetic.	Astronomic.
	° ′ ″	° ′ ″
Haiku:		
Trigonometric.	20 55 43.6	
Observatory.	20 56 4.0	20 56 2.6
Kaupo:		
Trigonometric.	20 37 38.1	
Observatory.	20 37 41.0	20 36 40.8
Difference.	18 23.0	19 21.8
Deflection of plumb-line.	....	0 29.4
Pakaoao:		
Trigonometric.	20 43 21.2	
Observatory.	20 43 21.6	21 42 51.0

LATITUDE.

The method employed was that described in the U. S. Coast and Geodetic Survey Report for 1880, Appendix No. 14. Pairs of stars were chosen whose zenith distances ranged from 0° to 50° and whose differences of zenith distances were not greater than 44 minutes. An examination of eleven stations where stars were observed up to these limits shows that the results from such stars are generally as satisfactory as those from normal pairs. The mean difference between the results for low stars and normal ones is not greater than the probable error of observation. Ninety seconds between pairs, and 30 seconds between stars of the same pair, was the shortest time allowed. The stars were chosen from Appendix No. 7, Report for 1876, and from the catalogue of 12,441 stars observed at the Cape of Good Hope by Stone. These two lists will furnish pairs at the rate of eight or ten per hour for latitudes near 20°. The instrument used was meridian telescope No. 1 (illustration No. 47).

The reductions of the stars in declination from the mean place at 1887.0 to the apparent place at the time of observation were effected by the use of the following formulæ:

$$-gdG \sin (G+\alpha)+dg \cos (G+\alpha)$$
$$[-hdH \sin (H+\alpha)+dk \cos (H+\alpha)] \sin \delta$$
$$di \cos \delta$$

Where the letters have the same signification as in the American Ephemeris. By this method the computations were considerably abridged with no sacrifice of essential accuracy. The apparent places for thirty pairs on two dates can thus be derived in seven hours.

The above formulæ are derived from the ordinary reduction formula by differentiation, considering the tabular differences of the quantities that vary with the date as the differential co-efficients of the quantities with respect to the time at the date already computed. The method is explained in detail in the Journal of the Franklin Institute, April, 1889, and also in Appendix No. 13 to this volume.

The mean declinations of the stars for the epoch 1887.0 were furnished by the Coast and Geodetic Survey Office. The treatment of the subject is set forth by Mr. C. A. Schott in the following extract from a communication to the Assistant in charge of the Office:

"The method of reduction and combination for obtaining mean places of stars (in declination) followed in the Computing Division of the Coast and Geodetic Survey, depends mainly on the investigation made by Lewis Boss in connection with the U. S. Northern Boundary Survey and as presented in his report of February, 1877, on the declination of fixed stars.

"The places obtained by the individual catalogues are weighted on a scale nearly identical with that used by Boss (pp. 160, 161 of his report) or by Auwers in his fundamental catalogue. For catalogues later than 1835 these weights vary between 0.5 and 6.

"With respect to the number of observations, n, the relative weights are put proportional to $\left(1 + \frac{6}{n}\right)^{-1}$ so that for instance 1, 6, and 60 observations would receive the relative weights 0.1, 0.5, and 0.9 nearly.

"The probable error of the unit of weight is taken equal to $\pm 0.''37$, a value intermediate between those of Boss and Auwers; that of the declination at the mean epoch is ± 0.37 times the (sum)$^{-\frac{1}{2}}$ of the weights; that of the proper motion is derived from the weights as explained below, and the tabular probable error is obtained by combining the last two.

"The systematic corrections to the declinations are taken from the report of Boss, page 175 *et seq.*, with some additional columns for special catalogues; these corrections depend on the declination argument alone, those depending on right ascensions being not considered.

"Unless the proper motion of a star (in declination) is given in Auwer's catalogues, it is specially made out from discussion of the individual values for the declination by each catalogue with application of the method of least squares and the use of weights, which latter depend on the square of the difference of time elapsed between some adopted average epoch (say 1855) and the epoch of the particular catalogue.

"When, however, there are no later observations than are used in the Northern Boundary Survey Catalogue of Boss, Newcomb's Zodiacal Stars, or Safford's declinations, or where later observations correspond pretty closely with those authorities, no such special calculation was believed necessary.

"In accordance with the above principles, the mean places of stars required by the Coast and Geodetic Survey are now made out and presented in tabular form by Mr. H. Farquhar, of the Computing Division, who has special charge of this class of computations."

Inclination of micrometer thread.

At Puuloa, Kahuku, and Waimea, the micrometer thread was not coincident with the tangent to the star's path when crossing the meridian. As this defect could not be remedied immediately, it became necessary to determine its inclination in order to correct the micrometer readings for those stars that were not observed at culmination. This was done by bisecting a number of stars at each station either before or after culmination, and noting the time and readings of the micrometer, and comparing these with the regular meridian observation. For north stars the extra bisections were made after culmination and for south stars before it; the position of the rack for counting the micrometer turns, which encroached considerably on the east side of the field, made this course necessary.

The reading of the micrometer was first corrected for the change in altitude of the star between the point of observation and the meridian. The difference between this corrected reading and the reading at culmination gave the error due to the inclination of the micrometer for this particular distance from the meridian and for a star of this declination. Dividing by the time in seconds and multiplying by the secant of the declination, we have the error in reading when an equatorial star is bisected one second from the meridian. This was done for a number of stars and the mean correction found to be 0.062 divisions.

The correction to be applied to any particular star would therefore be $0^d.062\ t \cos \delta$ and the correction to the latitude in seconds of arc $0''.02\ t \cos \delta$; t being the distance from culmination expressed in seconds of time. For stars bisected before the meridian the correction is negative, while for those after the meridian it is positive.

Micrometer.

The value of one revolution of the micrometer screw was determined eleven times during the course of the work. Five times, Polaris was used near west elongation, and the times were noted by the eye-and-ear method to the nearest second of time. The chronograph was used six times, somewhat faster moving stars being chosen, and the recorded times were read off to the nearest tenth of a second. The following table gives the stations, method, time, and results of the separate determinations:

Station.	Method.	Month.	Individual values.	Values for station.
			″	″
Waimea.	Eye and ear.	February.	64.38	64.36
Do.	Do.	Do.	.34	
Hanalei.	Do.	March.	.30	
Do.	Do.	Do.	.31	.31
Do.	Do.	Do.	.32	
Honolulu.	Chronograph.	June.	.36	
Do.	Do.	Do.	.37	.36
Do.	Do.	Do.	.35	
Pakaoao.	Do.	July.	.35	
Do.	Do.	Do.	.37	.37
Do.	Do.	Do.	.40	

Mean adopted value = 64″.350 ± 0″.01.

Level.

The value of one division of the level was determined at Hilo by means of the eye-piece micrometer.

Four determinations were made on different parts of the screw with the following results:

		Rev.	Rev.
From 0 turns to 10 turns	1 division =	.01423 ±	.00009
From 10 turns to 20 turns	=	46 ±	10
From 20 turns to 30 turns	=	25 ±	13
From 30 turns to 40 turns	=	31 ±	07
Adopted value	1 division =	.01429 ±	.00005

A previous determination at Kahuku Oahu gave 0.01428 revolutions, so the Hilo value is accepted, and we have finally 1 division of level, 0″.920.

Discussion of the results.

Assuming that the probable error of observation is the same for each pair of stars, its mean value from all the pairs is given by the formula:

$$e_0 = \sqrt{\frac{0.455\ \Sigma\Delta^2}{n - m}}$$

Where $\Sigma\Delta^2$ = sum of all the residuals obtained by comparing each mean result with the individual values for that pair; m = the number of pairs having at least two observations, and n = the total number of observations on the m pairs.

Admitting that e_0 represents the best attainable value for the probable error of observation of any pair, the probable error of any mean result from a pair will be

$$\varepsilon_{,} = \sqrt{\frac{0.455\,\Sigma\Delta^2}{n_{,}(n-m)}} = \frac{e_0}{\sqrt{n_{,}}}$$

Where $n_{,}$ is the number of observations on that particular pair.

If p = the total number of pairs observed at a station, a mean value of ε will be given by the formula

$$\varepsilon = \sqrt{\frac{e_0}{p-1}\left[\frac{1}{n}\right]}$$

$\left[\frac{1}{n}\right]$ being the sum of the reciprocals of the separate values of n.

The probable error of the latitude (φ) from any individual pair being given by

$$e_{\phi} = \sqrt{\frac{.455\ \Sigma\Delta\varphi^2}{p-1}}$$

the probable error of the mean of two declinations results from the formula

$$e_{\delta} = \sqrt{e_{\phi}^2 - \varepsilon^2}$$

The declinations of each of the stars of a pair are regarded as affected with the same probable error. The weight (w) assigned to each value of φ depends on the accuracy of the star's places and the number of times the pair was observed.

Hence the scale for weights is determined by

$$w = \frac{n}{ne_{\delta}^2 + e_0^2}$$

Where a star enters into combination with several others, these weights are modified by multiplying by $\frac{2}{c+1}$ where c is the number of pairs in the entire combination.

The finally adopted latitude is

$$\varphi_0 = \frac{\Sigma w\varphi}{\Sigma w}$$

with a probable error of

$$e_{\phi} = \sqrt{\frac{0.455\ \Sigma w\Delta\varphi^2}{(p-1)\,\Sigma w}}$$

Assuming that the probable error of observation (e_0) is equal to 0''.50 and the probable error of a single declination 0''.30, the following table has been calculated showing the relations between the number of pairs, the number of nights, and the probable error of the mean resulting latitude:

Number of nights of observations.	Number of pairs observed.					
	5	10	15	20	25	30
	Resulting probable error of mean result.					
	''	''	''	''	''	''
3	0.17	0.12	0.09	0.08	0.07	0.07
5	.15	.10	.08	.07	.06	.06
7	.13	.09	.07	.06	.06	.05

The following tables give the summary of results for all the stations and the separate values for each one of them:

Summary of results.

Station.	Latitude.	Number of determinations.	Number of pairs.	Number of nights.	e_0	ε	e_δ	w	e_ϕ
	° ′ ″				″	″	″		″
Puuloa.	21 19 15.6	74	29	3	±0.56	±0.37	±0.30	2.50	±0.09
Kahuku.	21 43 06.1	88	36	4	.46	.33	.48	2.27	.10
Waimea.	21 57 00.8	120	30	7	.45	.24	.25	3.80	.06
Koloa.	21 52 13.2	107	31	6	.43	.24	.50	2.26	.10
Hanalei.	22 12 56.5	97	33	6	.46	.28	.32	3.24	.07
Honolulu.	21 18 02.5	116	33	4	.43	.24	.46	2.52	.09
Kohala.	20 15 29.3	82	33	3	.42	.28	.59	1.93	.11
Hilo.	19 43 11.2	64	41	7	.53	.48	.49	1.93	.10
Ka Lae.	18 53 51.7	85	37	5	.51	.36	.56	1.71	.11
Kailua.	19 38 20.9	43	35	4	.51	.48	.67	1.41	.14
Haiku.	20 56 02.6	75	38	5	.53	.37	.49	1.95	.12
Pakaoao.	20 42 51.0	62	27	5	.47	.38	.50	2.11	.11
Hana.	20 45 38.9	68	47	5	.53	.48	.57	1.63	.11
Kaupo.	20 36 40.8	90	35	6	.68	.46	.49	1.42	.12
Means.	--------------	84	34	5	0.50	0.36	0.48	2.19	0.10

e_0 = probable error of single individual result for φ from one pair of stars.
ε = probable error of φ from observations on one pair.
e_δ = probable error of mean of two declinations.
w = weight of φ from one observation.
e_ϕ = probable error of resulting latitude from all observations.

Summary of results—Continued.

PUULOA. $\varphi=21° 19'.3$.

Star numbers.		Values from single observations.			Means.
		″	″	″	″
255	264	15.10	14.95	14.85	14.97
264	277	14.82	14.46	15.31	14.86
289	303	17.33	16.54	14.76	16.21
348	354	16.21	17.15	15.86	16.41
382	386	15.31	16.08	15.76	15.72
397	418	14.02	------	------	14.02
471	478	14.57	14.58	15.20	14.78
484	496	15.96	14.86	13.74	14.85
504	506	14.47	17.37	16.68	16.17
551	557	16.14	------	------	16.14
567	573	15.50	15.40	12.93	14.61
2640	600	16.00	15.17	17.81	16.33
615	620	14.72	15.84	15.78	15.45
630	637	15.98	15.83	------	15.90
652	654	15.49	15.06	14.24	14.93
662	672	15.08	14.73	15.99	15.27
686	689	15.02	15.75	------	15.38
706	715	16.84	15.81	------	16.32
729	3745	15.29	17.40	------	16.35
747	756	16.22	15.74	16.79	16.25
772	779	16.17	16,95	15.19	16.10
785	4342	15.89	14.48	14.16	14.84
804	809	15.18	15.44	15.07	15.23
4621	814	15.07	15.82	15.35	15.41
829	840	16.34	16.18	------	16.26
871	887	14.77	14.17	------	14.47
901	905	16.52	15.70	------	16.11
933	937	16.51	15.95	------	16.23
946	949	15.37	16.19		15.78
Mean.		------	------	------	*15.58

* Weighted mean depending on the probable errors of observation and declination.

Summary of results—Continued.

KAHUKU. $\varphi=21^{\circ}\ 43'.1$.

Star numbers.		Values from single observations.					Means.
		″	″	″	″	″	″
348	350	5.21	4.62	5.12	------	------	4.98
354	365	5.62	5.51	------	------	------	5.56
382	386	4.12	7.23	5.85	------	------	5.73
397	407	5.80	5.84	5.17	6.05	6.65	5.90
429	444	7.11	7.49	6.71	------	------	7.10
451	462	5.02	3.55	------	------	------	4.28
474	477	7.89	5.97	6.16	------	------	6.67
484	496	7.63	6.94	6.90	------	------	7.16
501	509	5.50	7.27	7.56	7.61	------	6.99
515	519	6.12	6.67	6.29	6.63	------	6.43
524	534	6.53	6.13	6.13	------	------	6.26
541	558	4.35	3.77	5.17	------	------	4.43
541	561	5.33	6.28	5.87	------	------	5.83
567	573	4.45	6.39	5.62	------	------	5.49
602	604	6.12	7.22	------	------	------	6.67
616	621	5.18	5.51	5.56	------	------	5.42
634	647	6.81	6.82	7.50	------	------	7.04
652	654	6.07	7.37	------	------	------	6.72
677	689	6.82	7.17	------	------	------	7.00
699	3531	7.31	6.66	------	------	------	6.99
707	725	6.36	6.29	------	------	------	6.32
742	745	5.67	6.63	------	------	------	6.15
752	755	8.48	7.18	------	------	------	7.83
765	773	5.42	6.16	------	------	------	5.79
808	815	7.19	6.36	6.62	------	------	6.72
866	873	5.14	5.08	------	------	------	5.11
5225	884	5.39	------	------	------	------	5.39
901	905	7.35	7.70	------	------	------	7.52
912	917	5.34	6.33	------	------	------	5.83
921	924	5.65	5.51	------	------	------	5.58
945	947	5.95	------	------	------	------	5.95
961	965	6.87	6.16	------	------	------	6.52
973	985	3.35	5.68	------	------	------	4.52
1022	1023	4.97	4.41	------	------	------	4.69
1045	1055	6.49	4.45	------	------	------	5.47
1065	1072	6.17	------	------	------	------	6.17
Mean.		------	------	------	------	------	6.07

Summary of results—Continued.

WAIMEA. $\varphi=21° 57'.0$

Star numbers.		Values from single observations.						Means.
		"	"	"	"	"	"	"
471	474	0. 61	1. 26	------	------	------	------	0. 93
496	516	0. 57	1. 58	0. 70	0. 97	1. 35	0. 93	1. 01
502	516	0. 48	1. 43	0. 07	0. 45	1. 56	0. 27	0. 71
524	534	0. 41	1. 81	3. 01	1. 23	1. 88	1. 79	1. 69
541	558	0. 80	1. 08	1. 43	1. 38	0. 24	0. 67	0. 93
541	561	0. 75	1. 28	1. 45	0. 50	------	------	1. 00
575	578	1. 15	1. 07	2. 11	1. 73	0. 55	------	1. 32
591	602	1. 44	0. 45	0. 76	------	------	------	0. 88
609	621	1. 74	0. 41	0. 05	0. 60	------	------	0. 70
606	621	0. 02	2. 10	1. 70	1. 86	------	------	1. 42
639	640	0. 12	0. 33	59. 91	------	------	------	0. 12
689	696	1. 96	1. 08	2. 03	0. 97	1. 38	------	1. 48
705	719	0. 96	0. 83	1. 00	------	------	------	0. 93
726	730	59. 61	1. 01	0. 94	------	------	------	0. 52
733	737	59. 55	1. 54	59. 68	1. 39	59. 67	------	0. 36
742	745	0. 64	2. 15	0. 28	------	------	------	1. 02
755	764	0. 77	0. 98	1. 95	0. 95	------	------	1. 16
4100	769	1. 17	0. 33	0. 28	58. 96	------	------	0. 19
795	797	1. 18	0. 61	1. 88	0. 79	------	------	1. 11
808	815	2. 14	1. 12	------	------	------	------	1. 63
819	825	0. 25	0. 75	0. 47	59. 85	------	------	0. 33
4786	835	0. 02	1. 04	0. 00	2. 32	------	------	0. 85
854	860	1. 01	0. 45	0. 96	1. 33	------	------	0. 94
866	873	59. 86	59. 38	0. 15	0. 05	------	------	59. 86
5225	884	0. 46	1. 56	0. 09	2. 25	------	------	1. 09
887	896	0. 50	0. 08	0. 00	59. 22	------	------	59. 95
900	903	0. 05	59. 98	58. 93	------	------	------	59. 65
906	911	0. 48	1. 57	59. 95	1. 79	------	------	0. 95
921	924	1. 38	0. 92	0. 92	------	------	------	1. 07
3131	659	1. 13	0. 49	0. 75	59. 93	------	------	0. 57
Mean.		------	------	------	------	------	------	0. 81

Summary of results—Continued.

KOLOA. $\varphi = 21° 52'.2$

Star numbers.		Values from single observations.					Means.
		"	"	"	"	"	"
575	578	13.42	12.71	13.18	------	------	13.10
591	602	13.57	13.33	------	------	------	13.45
609	621	13.54	12.17	12.82	13.19	------	12.93
616	621	14.79	15.36	15.62	14.18	------	14.99
628	2893	12.58	14.61	12.56	------	------	13.25
639	640	13.35	13.27	12.61	12.65	12.72	12.92
3131	659	12.61	12.73	12.55	13.53	------	12.86
689	696	15.36	14.44	15.13	15.10	------	14.98
705	719	13.58	12.83	11.87	------	------	12.76
726	730	11.64	14.08	13.10	12.75	13.56	13.03
733	737	12.21	11.34	12.32	------	------	11.95
742	745	14.94	14.20	13.52	16.16	------	14.71
755	764	12.79	12.03	11.61	13.80	------	12.56
4100	769	14.18	14.60	------	------	------	14.39
4143	774	12.89	11.65	12.95	12.32	------	12.46
783	4335	12.65	12.14	11.94	12.28	------	12.25
*2860	797	12.81	12.61	12.80	13.12	------	12.84
795	797	13.54	12.71	12.90	13.06	------	13.05
808	815	13.74	13.84	13.96	------	------	13.85
819	825	12.25	11.78	12.02	11.63	------	11.92
4786	835	12.51	12.59	12.93	------	------	12.68
839	4913	13.95	12.85	------	------	------	13.40
839	4920	13.43	12.99	13.23	------	------	13.22
854	860	14.17	12.66	14.16	13.28	------	13.57
866	873	15.18	14.29	14.23	14.32	------	14.50
5225	884	12.95	12.77	13.91	------	------	13.21
887	896	12.67	12.15	12.36	------	------	12.39
900	903	11.86	12.20	12.35	------	------	12.14
906	911	12.27	13.13	12.88	------	------	12.76
921	924	13.03	12.93	15.71	------	------	13.89
927	5827	12.07	13.15	13.14	------	------	12.79
Mean.		------	------	------	------	------	13.17

* B. A. C.

Summary of results—Continued.

HANALEI. $\varphi=22° 12'.9$

Star numbers.		Values from single observations.					Means.
		"	"	"	"	"	"
673	3294	56.11	56.86	56.20	------	------	56.39
704	3653	56.98	57.08	------	------	------	57.03
726	743	56.93	55.92	56.86	------	------	56.57
751	4018	56.24	56.33	54.85	------	------	55.81
766	768	55.38	55.82	56.40	------	------	55.87
770	4159	55.44	57.95	57.13	------	------	56.84
774	4240	57.92	56.90	56.03	------	------	56.95
801	820	57.61	56.65	------	------	------	57.13
805	820	57.80	55.93	56.35	------	------	56.69
828	4786	57.27	57.03	------	------	------	57.15
836	837	57.31	55.86	56.05	------	------	56.41
5055	864	57.24	57.68	55.79	56.61	------	56.83
894	896	57.27	56.66	------	------	------	56.96
901	907	56.14	55.38	54.10	------	------	55.21
910	913	55.81	56.26	55.73	57.14	------	56.24
921	924	56.72	56.15	------	------	------	56.43
927	5827	57.06	57.05	57.00	------	------	57.04
947	958	56.28	54.75	56.12	54.80	------	55.49
963	964	55.64	53.27	56.40	55.34	56.08	55.35
970	973	55.89	55.39	55.36	54.47	55.17	55.26
976	978	56.91	56.14	56.43	56.21	------	56.42
983	988	56.14	55.82	56.53	56.64	56.15	56.26
994	6415	56.74	55.71	------	------	------	56.22
6415	998	56.59	57.33	56.35	------	------	56.76
1000	1002	56.35	56.07	------	------	------	56.21
1004	1017	56.64	58.17	57.96	------	------	57.59
1004	1011	56.93	56.62	------	------	------	56.78
1004	1007	56.97	56.82	------	------	------	56.90
1022	1023	56.68	57.16	57.62	56.22	------	56.92
1030	1032	56.25	57.75	------	------	------	57.00
1158	1159	56.71	57.00	------	------	------	56.85
1165	1176	57.84	57.78	------	------	------	57.81
7891	1203	57.43	56.73	------	------	------	57.08
Mean.		------	------	------	------	------	56.51

Summary of results—Continued.

HONOLULU. $\varphi=21° 18'.0$

Star numbers.		Values from single observations.				Means.
		"	"	"	"	"
735	742	2.58	3.65	2.16	2.39	2.70
747	756	3.53	2.22	2.28	------	2.68
772	779	3.50	3.07	------	------	3.28
790	793	2.09	2.43	0.72	1.87	1.78
792	793	2.12	1.19	0.55	------	1.29
795	800	3.57	3.13	2.20	2.84	2.93
804	809	2.35	2.54	2.95	2.87	2.68
811	814	1.18	2.93	2.23	3.53	2.47
818	822	2.66	1.20	0.87	0.11	1.21
829	840	3.65	1.66	1.95	2.84	2.52
851	855	3.41	3.53	------	------	3.47
867	873	2.00	1.79	1.67	------	1.82
880	887	2.06	2.08	1.21	1.61	1.74
5336	895	2.45	1.36	2.16	2.12	2.02
901	905	2.12	2.40	1.75	1.88	2.04
919	929	3.17	2.64	1.78	3.21	2.70
933	937	3.74	3.08	3.58	3.17	3.39
946	949	3.04	3.52	------	------	3.28
955	956	2.54	2.18	2.95	------	2.55
963	971	2.88	2.20	------	------	2.54
984	991	0.78	2.29	2.19	3.15	2.10
997	6487	3.94	3.07	3.63	4.13	3.69
1004	1008	2.84	3.15	2.84	3.16	3.00
1017	1020	0.73	1.89	1.74	1.31	1.41
1032	1037	2.78	4.35(?)	3.77	------	3.63
1048	1050	1.54	0.42	0.80	1.17	0.98
1061	1072	2.43	2.73	3.61	------	2.92
1065	1072	2.09	1.94	1.80	------	1.94
1082	1086	1.96	3.01	3.36	2.77	2.78
1096	1097	2.13	2.80	4.52	------	3.15
1100	1104	1.53	1.30	1.71	1.25	1.45
1112	1121	2.77	3.61	3.14	3.25	3.19
1116	1121	2.65	2.67	1.70	1.99	2.25
Mean.		------	------	------	------	2.48

Summary of results—Continued.

KOHALA. $\varphi = 20° 15'.5$

Star numbers.		Values from single observations.			Means.
		″	″	″	″
4159	781	28.40	28.64	------	28.52
781	4298	29.30	29.78	------	29.54
793	803	29.86	29.99	------	29.92
803	806	29.99	30.80	------	30.40
816	822	27.74	28.33	27.46	27.84
3000	822	27.57	28.78	27.21	27.85
857	5059	28.72	29.04	28.40	28.72
868	875	31.37	29.84	30.33	30.51
881	882	29.54	28.60	27.71	28.62
899	905	28.49	27.73	28.71	28.31
917	918	28.84	30.22	------	29.53
5697	927	29.67	29.28	30.79	29.91
929	932	28.63	31.05	------	29.84
5806	940	30.48	30.41	30.28	30.39
950	6021	30.02	------	------	30.02
957	965	28.52	27.94	27.94	28.13
983	985	29.33	29.83	30.23	29.80
1014	1021	29.45	30.91	31.15	30.50
1029	6756	29.61	30.21	------	29.91
6885	1054	30.10	30.23	29.26	29.86
1059	6943	28.73	27.75	29.16	28.55
1069	1072	28.21	28.33	29.02	28.52
1085	1086	30.58	28.76	29.55	29.63
1091	1099	30.70	30.32	31.69	30.90
1116	1117	28.57	27.69	------	28.13
1112	1117	28.10	27.87	------	27.99
1127	1128	29.58	31.07	------	30.32
1138	1144	28.17	28.96	------	28.56
1159	1165	29.54	30.98	------	30.26
1170	7669	27.64	28.47	28.63	28.25
1170	7678	27.54	28.74	29.23	28.50
880	5293	30.96	30.33		30.65
5345	895	28.42	27.24		27.83
Mean.					29.33

Summary of results—Continued.

HILO. $\varphi = 19^\circ\ 43'.2$

Star numbers.		Values from single observations.				Means.	Star numbers.		Values from single observations.
		$''$	$''$	$''$	$''$	$''$			$''$
849	4969	10.45	12.62	------	------	11.53	1073	1076	12.08
868	875	10.34	10.19	------	------	10.26	1082	1091	10.33
879	880	11.34	10.02	------	------	10.68	1099	1109	12.97
883	885	11.08	11.93	------	------	11.50	1109	1115	11.30
893	898	11.23	11.52	11.59	------	11.45	6019	960	11.93
899	900	12.88	10.32	11.29	------	11.49	982	985	12.30
910	924	12.31	11.19	------	------	11.75	992	1000	12.85
928	932	10.95	12.04	12.39	12.27	11.91	1130	1133	13.54
5825	940	11.54	11.34	------	------	11.44	7436	1147	12.26
947	947	11.25	------	------	------	11.25	1147	7536	12.10
6072	966	11.42	11.75	------	------	11.58	1159	1165	10.83
971	973	11.31	8.49	------	------	9.90	1170	7718	10.52
977	978	10.68	10.07	------	------	10.38	1186	1194	10.99
1005	1008	12.54	11.13	------	------	11.84	1199	1204	12.90
1014	1021	10.30	9.48	------	------	9.89	1209	1217	10.64
1014	4039	12.43	10.92	------	------	11.68	1342	1346	9.47
1025	1030	10.78	11.49	------	------	11.14	1682	1697	9.62
1033	1048	11.44	10.96	11.00	------	11.13	1724	1725	10.67
1062	1072	11.17	11.59	------	------	11.38	1744	1750	9.07
							1761	1796	12.31
							1796	1798	9.33
							1825	1829	11.67
							Mean.		11.24

Summary of results—Continued.

KA LAE. $\varphi=18° 53'.9$

Star numbers.		Values from single observations.			Means.
		"	"	"	"
6388	995	50.46	50.68	52.30	51.15
999	1007	50.45	51.00	51.07	50.84
1014	1015	50.64	52.13	52.01	51.59
1018	1025	50.87	------	------	50.87
1077	1089	51.53	------	------	51.53
1027	1031	51.02	50.85	------	50.93
6903	1054	52.70	51.99	------	52.35
1110	1121	53.40	53.62	53.77	53.60
1128	1139	52.97	53.18	53.89	53.35
1146	1158	52.92	51.54	------	52.23
1164	1165	51.25	50.46	49.93	50.55
1175	1177	52.36	53.11	------	52.73
7791	1190	52.66	51.62	------	52.14
1190	7803	52.27	52.35	------	52.31
1195	1198	50.37	50.04	49.24	49.88
1198	1202	52.04	51.61	52.30	51.98
1214	1226	52.24	52.07	51.25	51.85
1231	1235	51.96	51.73	------	51.85
1239	1242	50.63	50.45	50.61	50.56
1262	8367	52.50	51.44	------	51.97
1317	1322	52.82	52.98	------	52.90
1345	1345	49.94	------	------	49.94
1355	1358	52.65	51.17	------	51.91
1430	1432	51.32	49.09	------	50.20
1435	1450	53.51	53.75	------	53.63
1507	1513	54.23	52.63	------	53.43
1522	1525	52.03	51.15	52.63	51.94
1549	1555	52.74	52.80	52.46	52.67
1602	1621	49.41	51.33	------	50.37
1630	1633	50.90	51.58	52.19	51.56
1638	1643	50.55	49.48	------	50.02
1654	1665	52.34	51.85	------	52.10
1712	1725	50.36	53.40	------	51.88
1765	1778	51.49	52.04	------	51.76
1784	1795	49.99	49.91	------	49.95
1815	1820	51.53	51.53	------	51.53
1900	11276	52.76	52.70	------	52.73
Mean.		------	------	------	51.72

Summary of results—Continued.

KAILUA. $\varphi = 19° 38'.3$

Star numbers.		Values from single observations.		Means.
		"	"	"
1082	1091	22.71	------	22.71
1099	1109	21.11	------	21.11
1109	1115	19.34	------	19.34
1130	1133	23.05	------	23.05
7436	1147	22.80	------	22.80
1147	7536	18.94	------	18.94
1159	1165	19.30	------	19.30
1170	7718	20.70	------	20.70
1186	1194	21.42	------	21.42
1199	1204	20.54	------	20.54
1209	1217	21.68	------	21.68
1322	1333	22.00	------	22.00
1342	1346	18.49	------	18.49
1428	1429	20.19	------	20.19
1471	1474	20.18	------	20.18
1588	1598	21.74	23.41	22.58
6456	1611	20.54	20.69	20.62
1608	1611	20.69	21.01	20.85
1660	1680	18.65	------	18.65
1682	1697	20.13	------	20.13
1724	1725	21.84	------	21.84
1744	1750	22.91	------	22.91
1796	1798	19.35	------	19.35
1815	1822	20.34	------	20.34
1825	1829	22.00	------	22.00
7351	1901	20.49	------	20.49
1898	1901	20.26	------	20.26
1902	1901	20.99	------	20.99
1904	1907	21.06	21.31	21.18
1928	1936	22.49	21.11	21.80
2017	2018	19.79	20.70	20.25
2022	2043	18.45	19.58	19.02
2054	2057	18.52	19.28	18.90
2077	2089	19.53	------	19.53
2091	2095	22.03	------	22.03
Mean.		------	------	20.86

Summary of results—Continued.

HAIKU. $\varphi=20° 56'.1$

Star numbers.		Values from single observations.					Means.
		"	"	"	"	"	"
1138	1140	2.91	------	------	------	------	2.91
1140	1143	3.38	------	------	------	------	3.38
1180	7771	3.19	------	------	------	------	3.19
1194	1200	1.59	------	------	------	------	1.59
1209	1218	1.26	1.78	3.05	------	------	2.03
1223	1228	0.39	4.55	2.70	------	------	2.55
8115	1234	2.18	2.47	------	------	------	2.32
8135	1234	1.67	2.24	------	------	------	1.96
1237	1239	1.78	2.35	2.28	2.42	------	2.21
1244	8261	3.92	4.20	3.55	4.30	------	3.99
1269	1275	3.84	4.92	------	------	------	4.38
8467	1301	3.39	2.12	2.46	------	------	2.66
8484	1301	3.19	2.37	2.61	------	------	2.72
8497	1301	1.37	2.67	3.13	------	------	2.39
1307	1312	2.64	1.65	1.88	1.93	------	2.02
1325	1326	2.32	0.48	1.20	1.69	------	1.42
1330	1333	1.44	3.08	------	------	------	2.26
1338	1342	1.88	4.01	2.34	2.36	------	2.65
1350	1352	2.26	3.28	3.49	2.90	------	2.98
1356	1358	4.14	------	------	------	------	4.14
1363	8999	3.66	2.24	------	------	------	2.95
1390	1398	3.86	4.74	4.15	3.59	3.57	3.98
1417	1419	0.21	0.56	2.46	2.46	1.62	1.46
1402	1408	1.51	2.84	2.51	------	------	2.29
1424	1430	2.75	2.17	1.80	------	------	2.24
1434	1442	2.23	0.59	------	------	------	1.41
1449	1450	3.07	3.73	------	------	------	3.40
1452	1464	1.22	1.06	------	------	------	1.14
Mean.		------		------	------	------	2.57

Summary of results—Continued.

PAKAOAO. $\varphi=20° 42'.8$

Star numbers.		Values from single observations.					Means.
		$''$	$''$	$''$	$''$	$''$	$''$
1216	1219	52.68	------	------	------	------	52.68
1223	1228	49.42	------	------	------	------	49.42
8141	1238	50.57	------	------	------	------	50.57
1238	8192	52.30	------	------	------	------	52.30
1269	1275	50.00	51.60	------	------	------	50.80
1314	1318	50.63	------	------	------	------	50.63
1325	1326	49.91	49.81	------	------	------	49.86
1330	1333	51.98	51.00	52.57	------	------	51.85
1339	8838	50.57	50.93	51.50	50.62	------	50.90
1350	1352	51.42	------	------	------	------	51.42
1356	1358	51.44	------	------	------	------	51.44
1357	1358	51.64	------	------	------	------	51.64
1363	8999	51.06	51.16	50.36	51.08	------	50.91
1378	1387	51.79	51.55	51.53	51.68	50.87	51.48
139[illegible]	1398	50.02	49.37	50.32	50.66	------	50.09
1402	1408	50.44	50.75	49.97	51.31	------	50.62
1417	1419	49.14	50.39	50.64	------	------	50.05
1430	1445	52.18	51.92	52.34	51.58	------	52.00
1449	1450	49.09	51.88	52.13	------	------	51.03
1452	1464	49.90	51.15	50.64	50.18	------	50.47
1474	1492	52.90	50.55	------	------	------	51.72
1496	1498	51.47	------	------	------	------	51.47
1503	1507	51.74	52.08	------	------	------	51.91
1513	1522	51.29	53.13	------	------	------	52.21
1527	1527	49.15	------	------	------	------	49.15
1549	1551	49.20	------	------	------	------	49.20
1562	10107	50.82	51.04	------	------	------	50.93
Mean.		------	------	------	------	------	50.99

HANA. $\varphi=20° 45'.7$

Star numbers.		Values from single observations.					Star numbers.		Values from single observations.
		″	″	″	″	″			″
58	67	39.81	------	------	------	39.81	1235	1241	39.97
1252	1257	39.85	------	------	------	39.85	1325	1326	38.50
1269	1275	40.03	38.54	40.02	38.23	39.21	1346	1358	39.45
8445	1283	39.84	------	------	------	39.84	1356	1358	40.78
1283	8516	38.66	39.84	39.62	------	39.37	1357	1358	41.43
1308	1312	38.81	38.18	------	------	38.50	1369	1369	40.67
1330	1333	42.09	40.45	41.38	------	41.31	1378	1387	40.18
1402	1408	39.45	39.37	------	------	39.41	1390	1398	37.65
1417	1419	37.96	37.64	------	------	37.80	1471	1486	37.83
1434	1442	37.51	39.40	------	------	38.45	1496	1498	39.61
1449	1450	39.13	39.00	------	------	39.06	1503	1507	39.16
1452	1464	35.91	37.85	------	------	36.88	1513	1522	38.91
1643	1646	39.71	39.73	------	------	39.72	1531	1537	37.71
1650	1654	36.72	37.98	------	------	37.35	1562	10107	36.89
1660	1669	38.74	37.42	------	------	38.08	10174	1575	38.04
1668	1669	38.75	------	------	------	38.75	1578	1581	39.11
1682	1684	39.50	39.84	39.08	------	39.47	1578	1582	40.59
2095	2104	38.81	------	------	------	38.81	1603	1615	38.96
1692	1697	39.14	38.32	38.74	------	38.73	1638	1639	37.58
1699	1705	39.72	38.06	------	------	38.89	1677	1680	39.50
							1715	1720	39.29
							1851	1860	38.63
							11238	1900	37.36
							1907	1912	38.27
							1944	1947	37.87
							2082	2087	39.15
							2179	2	40.43
							Mean.		38.93

Summary of results—Continued.

KAUPO. $\varphi=20° 36'.7$

Star numbers.		Values from single observations.				Means.
		″	″	″	″	″
1269	1275	40.11	41.08	41.14	------	40.77
1283	8516	39.60	40.36	40.18	------	40.05
1308	1312	43.20	41.11	40.58	39.02	40.98
1325	1326	38.46	39.77	------	------	39.11
1330	1335	39.15	41.64	{ 40.60 40.54	42.57 40.61 }	40.85
1337	1341	42.02	42.32	41.93	42.71	42.24
1346	1358	39.47	39.10	------	------	39.28
1356	1358	40.71	39.31	------	------	40.01
1357	1358	39.50	39.03	------	------	39.26
1378	1387	40.64	39.08	39.62	------	39.78
1390	1398	41.32	41.52	40.26	40.00	40.77
1402	1408	42.36	------	------	------	42.36
1410	9344	41.47	41.50	39.37	------	40.78
1427	9445	40.85	42.34	------	------	41.60
1427	9452	41.87	41.39	------	------	41.63
1427	9463	42.15	------	------	------	42.15
1449	1450	41.89	40.86	40.38	------	41.04
1452	1464	40.86	38.16	------	------	39.51
1474	1492	40.31	42.16	43.69	41.51	41.92
1496	1498	39.87	40.04	------	------	39.95
1498	1499	40.77	39.97	39.68	------	40.14
1503	1507	41.01	40.97	39.29	41.74	40.75
1517	1517	42.52	41.41	40.22	------	41.38
1527	1527	38.54	40.43	39.58	39.75	39.58
1578	1581	38.60	39.90	------	------	39.25
1578	1582	39.59	------	------	------	39.59
1643	1646	41.24	42.86	------	------	42.05
1668	1669	44.40	41.67	-----	------	43.03
1692	1697	40.14	43.28	------	------	41.70
1699	1705	40.03	40.21	------	------	40.12
1711	1715	43.06	40.23	------	------	41.65
1758	1771	41.45	41.44	------	------	41.44
1775	1778	40.69	39.22	------	------	39.95
1783	1798	40.46	38.66	------	------	39.56
1825	1837	39.83	39.43	------	------	39.63
Mean.		------	------	------	------	40.75

Observations and reductions for Honolulu.

Observations were made on four nights, using thirty-three pairs of stars and giving one hundred and sixteen determinations. The latitude of the British transit of Venus pier, as deduced by Captain Tupman, is the result of observations on thirty-five nights with two hundred and twenty-four determinations. The methods employed were, however, essentially different. The English measured the co-latitude directly, using an alt-azimuth instrument. Captain Tupman's latitude reduced to the Government observatory gives 21° 18′ 2″.32, so that the discrepancy between the two determinations is 0″.16. The distance between the two stations is about 620 feet. In order to compare the methods, in point of view of facility of computation, economy of time in observation, or accuracy of the final result, the observations and reductions are given in full.

Date.	Star No.	N. or S.	Revolutions micrometer.	Level.		Apparent declination.	Corrections.			φ=21° 18′
				N.	S.		Micrometer.	Level.	Ref. (Mer.).	
			t.	*d.*	*d.*	° ′ ″	′ ″	″	″	″
April	735	S.	20.415	35.0	40.0	17 55 43.05				
5	742	N.	20.030	38.5	37.0	24 39 58.93	+ 0 12.39	—0.80	0.00	2.58
			19.435	44.5	38.5	43.08				
6			19.110	43.5	40.0	58.97	10.45	+2.18	0.00	3.65
			20.220	40.0	46.0	43.11				
7			19.900	48.0	38.5	59.01	10.30	+0.80	0.00	2.16
			19.610	41.0	48.5	43.15				
8			19.220	46.0	44.0	59.06	12.55	—1.26	0.00	2.39
	747	N.	22.265	42.0	41.5	33 41 28.82				
6	756	S.	20.675	40.0	44.5	8 56 22.44	— 0 51.16	—0.92	—0.02	3.53
			20.885	50.0	36.5	28.87				
7			19.210	38.0	49.5	22.47	53.89	+0.46	—0.02	2.22
			20.515	54.0	36.5	28.92				
8			18.930	31.5	59.5	22.51	51.00	—2.41	—0.02	2.28
	772	S.	24.890	41.0	44.0	17 59 8.35				
6	779	N.	11.475	47.5	37.5	24 22 31.93	+ 7 11.63	+1.61	+0.12	3.50
			26.690	29.5	58.5	8.40				
7			13.240	58.5	29.5	34.00	12.75	0.00	+0.12	3.07
	790	N.	29.125	37.0	39.0	24 31 2.41				
5	793	S.	7.340	39.0	37.5	18 28 24.24	—11 40.93	—0.11	—0.19	2.09
			30.105	54.5	31.0	2.48				
6			8.350	29.0	56.0	24.30	39.97	—0.80	—0.19	2.43
			30.780	51.0	37.5	2.55				
7			8.970	35.5	52.5	24.36	41.74	—0.80	—0.19	0.72
			31.420	50.5	42.0	2.62				
8			9.690	37.0	55.5	24.42	39.16	—2.30	—0.19	1.87
	792	N.	25.900	37.5	39.0	24 27 34.57				
5	793	S.	7.340	39.0	37.5	18 28 24.24	— 9 57.17	0.00	—0.17 (+0.06)	2.12
			26.915	54.5	31.0	34.64				
6			8.350	29.0	56.0	24.30	57.33	—0.80	—0.17 (+0.02)	1.19
			26.550	50.5	38.0	34.71				
7			7.970	35.5	52.5	24.36	57.81	—1.03	—0.17 (+0.03)	0.55

Observations and reductions for Honolulu—Continued.

Date.	Star No.	N. or S.	Revolutions micrometer.	Level.		Apparent declination.	Corrections.			$\varphi=21°\ 18'$
				N.	S.		Micrometer.	Level.	Ref. (Mer.).	
April			*t.*	*d.*	*d.*	° ′ ″	′ ″	″	″	″
5	795	N.	29.050	44.0	32.0	36 48 21.37				
	800	S.	12.320	37.0	39.0	6 5 38.07	− 8 58.29	+2.30	−0.16	3.57
			28.830	48.0	37.5	21.46				
6			12.170	36.5	49.0	38.11	56.03	−0.46	−0.16	3.13
			26.560	51.0	38.0	21.55				
7			9.905	34.5	54.5	38.14	55.87	−1.61	−0.16	2.20
			28.180	48.5	44.0	21.64				
8			11.550	40.0	52.5	38.18	55.07	−1.84	−0.16	2.84
5	804	S.	29.620	37.0	39.0	13 4 57.82				
	809	N.	10.310	46.5	29.5	29 10 17.02	+10 21.30	+3.45	+0.18	2.35
			29.425	36.5	49.5	57.87				
6			10.025	51.0	35.0	17.10	24.19	+0.69	+0.18	2.54
			28.405	40.5	48.0	57.92				
7			8.970	48.0	41.0	17.19	25.32	−0.11	+0.18	2.95
			29.040	37.5	55.0	57.98				
8			9.520	48.5	44.0	17.27	28.06	−2.99	+0.18	2.87
5	811	S.	17.830	29.0	47.0	− 1 29 15.50				
	814	N.	21.115	49.0	27.0	44 8 47.49	− 1 45.70	+0.92	−0.04	1.18
			19.330	34.0	52.0	15.48				
6			22.495	49.5	37.0	47.61	41.83	−1.26	−0.04	2.93
			18.015	32.0	57.0	15.47				
7			21.150	50.5	38.5	47.73	40.87	−2.99	−0.04	2.23
			16.965	39.0	54.0	15.45				
8			20.130	47.0	45.5	47.85	41.83	−0.80	−0.04	3.53
5	818	N.	33.490	34.0	32.0	31 00 20.10				
	822	S.	7.780	37.0	29.5	12 3 15.79	−13 47.22	+2.18	−0.24	2.66
			32.930	44.0	42.5	20.19				
6			7.290	39.0	47.5	15.85	44.97	−1.61	−0.24	1.20
			33.400	51.0	38.0	20.28				
7			7.740	35.0	54.0	15.91	45.61	−1.38	−0.24	0.87
			32.750	59.0	34.0	20.38				
8			7.150	25.0	68.0	15.96	43.68	−4.14	− 0.24	0.11
5	829	S.	25.540	34.0	42.0	12 17 30.59				
	840	N.	14.125	40.0	37.0	30 6 24.26	+ 6 7.28	−1.15	+0.10	3.65
6			25.250	39.5	47.0	30.64				
			13.935	47.5	40.0	24.37	4.06	0.00	+0.10	1.66
7			24.035	28.0	61.0	30.69				
			12.660	57.5	32.0	24.48	5.99	−1.72	+0.10	1.95
8			22.570	40.0	53.0	30.76				
			11.120	46.0	47.5	24.58	8.40	−3.33	+0.10	2.84
5	851	S.	35.285	38.5	38.5	15 24 26.39				
	855	N.	5.795	41.0	37.0	26 40 0.25	+15 48.94	+0.92	+0.23	3.41
6			33.575	43.0	44.5	26.50				
			4.020	42.5	45.5	0.36	50.93	−1.03	+0.23	3.56

Observations and reductions for Honolulu—Continued.

Date.	Star No.	N. or S.	Revolutions micrometer.	Level. N.	Level. S.	Apparent declination.	Corrections. Micrometer.	Corrections. Level.	Corrections. Ref. (Mer.).	φ=21° 18′
April			t.	d.	d.	° ′ ″	′ ″	″	″	″
5	867	S.	43.810	43.0	35.0	10 12 39.01				
	873	N.	3.380	39.5	38.5	31 39 58.44	+21 40.83	+2.07	+0.38	2.00
7			42.535	34.0	55.5	39.13				
			2.070	57.0	33.0	58.64	41.96	+0.57	+0.38	1.79
8			42.500	46.0	49.0	39.19				
			2.020	48.5	46.0	58.73	42.44	−0.11	+0.38	1.67
5	880	N.	18.920	41.5	36.5	40 16 19.02				
	887	S.	20.325	36.5	41.5	2 18 14.72	+ 0 45.20	0.00	−0.01	2.06
6			20.080	42.5	46.0	19.17				
			21.540	42.0	46.5	14.75	46.97	−1.84	−0.01	2.08
7			18.070	47.0	43.0	19.32				
			19.450	42.5	47.5	14.78	44.40	−0.23	−0.01	1.21
8			18.100	53.0	41.5	19.48				
			19.575	35.0	59.5	14.82	47.46	−2.99	−0.01	1.61
5	5336	S.	15.320	35.0	44.0	− 7 34 38.64				
	895	N.	25.060	42.5	35.5	50 21 11.44	− 5 13.38	−0.46	−0.11	2.45
6			15.160	39.0	49.5	38.65				
			24.865	43.5	45.0	11.63	12.26	−2.76	−0.11	1.36
7			14.510	42.5	47.5	38.66				
			24.200	42.0	48.0	11.82	11.78	−2.53	−0.11	2.16
8	5336	S.	15.535	42.0	52.5	− 7 34 38.66				
	895	N.	25.115	39.0	55.5	50 21 12.01	− 5 8.24	−6.21	−0.11	2.12
5	901	N.	32.160	50.0	29.0	32 28 40.43				
	905	S.	8.380	28.5	50.0	10 32 54.95	−12 45.12	−0.23	−0.22	2.12
6			32.235	51.0	37.5	40.57				
			8.475	36.0	52.5	55.02	44.48	−0.69	−0.22	2.40
7			31.060	54.0	36.5	40.71				
			7.405	26.0	64.5	55.09	41.10	−4.83	−0.22	1.75
8			30.225	56.0	39.0	40.86				
			6.595	26.5	68.0	55.17	40.27	−5.64	−0.22	1.88
5	919	N.	2.535	35.0	43.5	42 4 1.74				
	929	S.	35.915	39.0	40.5	− 0 3 39.49	+17 54.00	−2.30	+0.35	3.17
6			2.620	55.0	34.0	1.93				
			36.030	25.5	63.5	39.47	54.97	−3.91	+0.35	2.64
7			2.550	46.0	45.5	2.12				
			35.730	51.0	40.5	39.45	47.57	+2.53	+0.35	1.78
8			3.820	48.5	46.5	2.31				
			37.005	54.5	40.5	39.41	47.73	+3.68	+0.35	3.21
5	933	S.	20.635	31.0	48.5	9 53 6.96				
	937	N.	11.990	49.5	29.5	32 33 42.92	+ 4 38.15	+0.57	+0.08	3.74
6			21.390	34.0	55.0	7.03				
			12.730	53.5	35.5	43.10	38.63	−0.69	+0.08	3.08
7			19.170	35.5	56.0	7.10				
			10.495	54.5	37.5	43.27	39.12	−0.80	+0.08	3.58

Observations and reductions for Honolulu—Continued.

Date.	Star No.	N. or S.	Revolutions micrometer.	Level. N.	Level. S.	Apparent declination.	Corrections. Micrometer.	Corrections. Level.	Corrections. Ref. (Mer.).	$\varphi=21° 18'$
			t.	*d.*	*d.*	° ′ ″	′ ″	″	″	″
April 8			19.065	41.0	53.5	32 33 7.17				
			10.385	50.5	44.5	43.44	+ 4 39.28	−1.49	+0.08	3.17
6	946	N.	14.740	45.0	44.5	31 16 34.32				
	949	S.	25.115	42.5	47.0	11 8 25.78	+ 5 33.81	−0.92	+0.10	3.04
8			12.145	54.0	41.0	34.66				
			22.570	36.0	59.0	25.95	35.42	−2.30	+0.10	3.52
5	955	N.	14.360	46.0	33.5	43 47 27.34				
	956	S.	33.500	34.5	45.0	− 1 31 55.29	+10 15.83	+0.46	+0.20 (+0.03)	2.54
6			13.500	50.5	39.0	27.56				
			32.655	38.0	51.5	55.30	16.31	−0.46	+0.20	2.18
7			12.475	60.0	31.5	27.78				
			31.665	29.5	62.0	55.31	17.44	−0.92	+0.20	2.95
6	963	N.	15.335	50.5	38.5	39 49 5.88				
	971	S.	27.540	34.5	54.5	2 33 57.93	+ 6 32.70	−1.84	+0.12	2.88
7			15.390	58.0	34.5	6.09				
			27.620	26.5	65.0	57.97	33.50	−3.45	+0.12	2.20
5	984	N.	10.875	38.0	42.5	38 48 15.72				
	991	S.	28.860	41.0	39.0	3 28 33.29	+ 9 36.67	−0.57	+0.18	0.78
6			9.560	53.0	36.5	15.94				
			27.565	32.5	57.0	33.34	39.31	−1.84	+0.18	2.29
7			9.060	49.5	43.0	16.16				
			27.090	37.0	56.0	33.39	40.11	−2.87	+0.18	2.19
8			9.380	56.0	40.0	16.37				
			27.450	32.5	63.0	33.44	41.40	−3.33	+0.18	3.15
5	997	N.	26.505	47.0	33.5	55 24 34.65				
	6487	S.	13.850	37.0	43.5	−12 34 55.33	− 6 47.17	+1.61	−0.16	3.94
6			26.015	49.0	40.5	34.93				
			13.370	41.0	48.5	55.23	46.85	+0.23	−0.16	3.07
7			24.320	55.0	38.0	35.21				
			11.765	33.0	60.0	55.13	43.95	−2.30	−0.16	3.63
8			25.520	52.0	43.5	35.48				
			12.975	38.5	57.0	55.03	43.63	−2.30	−0.16	4.13
5	1004	N.	4.600	48.5	31.5	34 50 19.73				
	1008	S.	38.340	28.5	51.5	7 9 36.92	+18 5.58	−1.38	+0.32	2.84
6			3.855	57.5	32.0	19.94				
			37.625	27.0	62.0	36.99	6.55	−2.18	+0.32	3.15
7			4.130	52.0	41.0	20.15				
			37.965	31.0	62.5	37.06	8.64	−4.72	+0.32	2.84
8			3.170	66.0	29.5	20.36				
			37.035	17.5	78.0	37.14	9.61	−5.52	+0.32	3.16
5	1017	S.	11.785	37.5	42.0	9 4 11.23				
	1020	N.	26.590	43.0	36.5	33 47 42.30	− 7 56.35	+0.46	−0.14	0.73
6			13.710	42.0	47.0	11.31				
			28.405	42.5	46.5	42.51	52.81	−2.07	−0.14	1.89

Observations and reductions for Honolulu—Continued.

Date.	Star No.	N. or S.	Revolutions micrometer.	Level. N.	Level. S.	Apparent declination.	Corrections. Micrometer.	Corrections. Level.	Corrections. Ref. (Mer.).	$\varphi=21° 18'$
April			*t.*	*d.*	*d.*	° ′ ″	′ ″	″	″	″
7			13.150	45.5	48.0	33 47 11.39				
			27.840	42.5	51.0	42.72	− 7 52.65	−2.53	−0.14	1.74
8			13.075	44.0	51.5	11.48				
			27.840	50.0	45.5	42.93	55.06	−0.69	−0.14	1.31
5	1032	N.	2.790	46.5	33.5	26 29 56.75				
	1037	S.	35.110	28.0	52.0	15 31 33.48	+17 19.89	−2.53	+0.30	2.78
6			3.020	52.0	37.0	56.93				
			35.320	36.0	53.0	33.60	19.25	−0.46	+0.30	4.35
7			1.230	51.5	42.0	57.11				
			33.775	22.0	71.0	33.72	27.14	−9.08	+0.30	3.77
5	1048	S.	11.195	19.0	60.0	18 24 55.35				
	1053	N.	31.635	59.0	20.5	24 33 6.56	−10 58.66	−0.57	−0.18	1.54
6			8.230	38.0	51.0	55.49				
			28.730	49.0	40.0	6.73	59.59	−0.92	−0.18	0.42
7			8.260	33.0	59.0	55.63				
			28.710	54.0	38.0	6.90	57.98	−2.30	−0.18	0.80
8			10.410	48.5	47.5	55.77				
			30.825	40.5	55.5	7.08	56.85	−3.22	−0.18	1.17
6	1061	N.	6.250	47.0	42.0	24 43 55.98				
	1072	S.	15.135	41.5	47.0	17 42 37.16	+ 4 45.89	−0.11	+0.08	2.43
7			5.470	51.0	41.0	56.15				
			14.410	37.0	54.5	37.30	47.65	−1.72	+0.08	2.73
8			4.740	49.5	46.5	56.32				
			13.785	37.0	59.0	37.44	51.02	−4.37	+0.08	3.61
6	1065	N.	31.835	44.0	44.5	25 11 24.71				
	1072	S.	15.135	41.5	47.0	17 42 37.16	− 8 57.32	−1.38	−0.15	2.09
7			31.080	49.0	43.0	24.89				
			14.410	37.0	54.5	37.30	56.36	−2.64	−0.15	1.94
8			30.425	50.5	45.5	25.06				
			13.785	37.0	59.0	37.44	55.39	−3.91	−0.15	1.80
5	1082	S.	19.475	35.5	44.5	17 11 34.62				
	1086	N.	22.320	46.0	34.5	25 27 31.29	− 1 31.54	+0.57	−0.02	1.96
6			17.850	40.0	49.0	34.76				
			20.550	42.0	47.0	31.47	26.87	−3.22	−0.02	3.01
7			16.490	44.0	47.0	34.90				
			19.240	43.5	47.5	31.65	28.48	−1.61	−0.02	3.36
8			18.485	44.5	51.5	35.03			(+0.20)	
			21.195	44.0	52.0	31.83	27.19	−3.45	−0.02	2.77
5	1096	S.	11.565	42.5	38.0	4 0 35.21				
	1097	N.	30.380	39.0	41.5	38 55 39.25	−10 5.37	+0.46	−0.19	2.13
6			12.500	41.5	47.5	35.27				
			31.220	43.0	46.0	39.49	2.32	−2.07	−0.19	2.80
7			10.550	35.5	55.0	35.33				
			29.150	40.5	50.0	39.73	9 58.45	−4.37	−0.19	4.52

Observations and reductions for Honolulu—Continued.

Date.	Star No.	N. or S.	Revolutions micrometer.	Level. N.	Level. S.	Apparent declination.	Corrections. Micrometer.	Corrections. Level.	Corrections. Ref. (Mer.).	$\varphi=21°\ 18'$
			r.	*d.*	*d.*	° ′ ″	′ ″	″	″	″
April	1100	N.	28.035	40.0	40.0	31 23 35.39				
5	1104	S.	8.040	41.5	38.5	11 33 53.35	−10 43.34	+0.69	−0.19	1.53
6			29.260	50.5	38.5	35.60				
			9.335	34.0	54.5	53.46	41.09	−1.95	−0.19	1.30
7			30.960	43.5	47.0	35.81				
			11.075	40.5	50.0	53.57	39.80	−2.99	−0.19	1.71
8			29.205	51.0	45.0	36.03				
			9.365	34.0	62.0	53.67	38.35	−5.06	−0.19	1.25
	1112	N.	12.035	47.5	33.0	28 13 47.38	+ 3 4.68	+0.46	+0.05	2.77
5	1116	N.	24.325	47.0	34.0	28 26 58.67	− 3 30.73	+0.11	−0.05	2.55
	1121	S.	17.775	34.0	46.5	14 16 7.78				
6			12.405	54.0	34.5	47.58	+ 7.74	−1.95	+0.05	3.61
			24.730	54.5	34.5	58.87	− 28.82	−1.84	−0.05	2.67
			18.240	30.0	58.0	7.90			(+0.03)	
7			12.330	48.0	42.0	47.78	+ 8.06	−2.87	+0.05	3.14
			24.690	50.0	41.0	59.07	− 29.62	−2.18	−0.05	1.70
			18.175	36.0	54.5	8.02			(+0.01)	
8			12.750	44.5	51.5	47.97	+ 9.51	−4.37	+0.05	3.25
			25.090	45.0	51.0	59.27	− 27.53	−4.14	−0.05	1.99
			18.640	42.0	54.0	8.15				

The care taken in the preparation of the mean declinations of the stars observed seemed to warrant their publication; and, in order that they might be available for future latitude observations in the islands, their right ascensions for 1887, annual variations, precessions, etc., have been calculated and are given in the following pages.

The work was done in the Computing Division by Mr. Henry Farquhar, to whose excellent judgment in questions relating to star places the value of the list is due.

The first column gives the star number as found in the Coast and Geodetic Survey Report for 1876, Appendix No. 7. When the star does not appear in this list the number given is taken from Stone's Catalogue of 12,441 stars observed at the Cape of Good Hope. Numbers above 2179 refer to the latter list.

The catalogues consulted are indicated as follows:

Designation.	Observatory.	Conductor of observations.	Epoch.	Editor or source.
a	Edinburgh.	Henderson.	1834–'44	Smyth.
b	Do.	Smyth.	54–'69	
c	Armagh.	Robinson.	28–'54	
d	Do.	Do.	59–'82	Dreyer.
e	Radcliffe.	Johnson.	40–'54	Main.
f	Do.	Do.	54–'61	Do.
g	Do.	Main.	62+	

Designation.	Observatory.	Conductor of observations.	Epoch.	Editor or source.
h	Madras.	Jacob.	1850±	Smyth.
i	Greenwich.	Airy.	36–'47	
j	Do.	Do.	48–'53	
k	Do.	Do.	54–'60	
l	Do.	Do.	61–'67	
m	Do.	Do.	68–'76	
n	Glasgow.	Grant.	60–'81	
o	Bonn.	Argelander.	45–'67	
p	Washington.	----------	45–'77	Yarnall.
q	Harvard.	Rogers.	70–'79	
r	Capitoline, Rome.	Respighi.	75–'77	
s	Leiden.	Kaiser.	64–'70	
t	Pulkowa.	Struve.	45±	
u	Do.	Do.	65±	Auwers [A. G. fund. Cat.].
v	Cape.	Maclear.	34–'40	Stone.
w	Do.	Do.	49–'52	Gill.
x	Do.	Stone.	71–'79	
y	Melbourne.	Ellery.	63–'70	
z	Cordoba.	Gould.	72–'83	
+	Brussels, etc.	Quetelet, etc.	57+	Safford.
+	Leipzig.	Engelmann.	67±	Auwers, Safford.
+	Harvard.	Rogers.	83–'85	
+	Ann Arbor.	Schæberle.	79±	M. S.

The magnitudes are from Pickering's Photometry (Harvard Observatory Annals, vol. 14). In cases of variable stars a magnitude about the brightest attained is set down, followed by the sign +. Southern stars not in the Harvard Photometry have magnitudes taken from Gould (Z). These are of two classes, those in the "Uranometria Argentina" to tenths (here corrected by —0.2 as in Pickering), and others to quarters of a magnitude (here unaltered). Double stars not noted separately by Pickering have the *difference* taken for some other authority designated by the appropriate letter, the magnitude of the aggregate, or of the principal star, depending on Pickering, as in the other cases.

The declinations are on a system in which the proper motions of Auwers, derived from Bradley, are used, and the places of his fundamental catalogue corrected by the difference between it and that of Boss (Northern Boundary Survey Report) for 1875.

Probable errors are estimated from the number and weight of authorities used and from the time between their average epoch and 1887.

The change in one hundred years of the annual precession in declination is taken from catalogues of epoch from 1864 to 1880. It may in many cases be wrong by one to three units in the last place for 1887.

A hyphen between two letters in the list of authorities for declination denotes the use of all intervening letters.

Mean places of Hawaiian latitude stars.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
2	2.1	0 2 33	+3.1	+28 27 59.57	±0.1	−0.156	+20.052	−0.012	a, b, e, f, i–n, p–v, x, y, +
58	5.7	40 38	3.1	14 51 32.04	0.25	−0.055	19.739	0.087	a, c, d, g, l, n, +
67	{ 6.4	43 49	3.2	27 5 42.54	0.3	−0.01	19.688	0.095	a, c, f, g, l, n, p.
	{ 6.3	43 49	3.2	27 5 40.13	0.2	−0.01	19.688	0.095	c, f, l, n, p, r.
72	5.8	48 36	3.2	18 34 31.27	0.25	−0.015	19.604	0.104	a, c, g, l–n, +
73	5.4	0 48 55	3.2	23 0 57.55	0.2	−0.045	19.599	0.105	c, f, g, l, m, r.
255	4.7	2 51 32	3.8	39 12 35.07	0.3	−0.045	14.695	0.384	a, c, e, i, r.
264	2.7	2 56 22	3.1	3 38 42.50	0.1	−0.73	14.402	0.323	a, b, e, f, i–n, p, q, s–v, x, y, +
277	4.7	3 4 0	3.9	39 10 53.76	0.25	+0.02	13.931	0.408	a, c, e, l, m, r.
289	4.8	11 40	3.7	33 48 30.88	0.3	−0.02	13.440	0.408	a, c, l–n, r.
303	3.8	18 44	3.2	8 37 49.98	0.1	−0.068	12.974	0.363	a, c, e, f, i–n, p, q, t, u, x, +
348	5.1	42 5	3.3	10 47 41.51	0.2	−0.025	11.353	0.398	a, c, i–n, p, v.
350	5.2	42 24	3.8	32 44 38.85	0.25	0.00	11.330	0.458	a, c, l, i, r.
354	3.1	47 2	3.8	31 32 49.95	0.15	−0.002	10.992	0.462	a, d, i, j, l, m, p–r, t, u, +
365	3.6+	3 54 25	3.3	12 10 12.93	0.15	−0.009	10.447	0.417	a, c, e, f, i–m, p, q, t, u.
382	5.7	4 1 5	4.0	37 44 35.11	0.2	−0.19	9.946	0.506	a, c, f, l, m, p, r.
386	5.7	5 19	3.2	5 13 41.65	0.3	+0.01	9.622	0.410	a, c, f, l, n.
397	5.0	7 48	3.3	8 58 34.55	0.3	−0.04	9.430	0.422	a, c, l, n.
407	5.1	13 4	3.9	34 17 34.38	0.2	+0.001	9.020	0.509	a, c, l, m, r, u.
418	5.6	17 9	3.9	33 52 4.93	0.25	−0.04	8.700	0.512	a, c, l, m, p, r.
429	4.9	20 13	3.4	14 27 27.06	0.35	−0.03	8.458	0.450	a, c, l.
444	5.6	27 34	3.8	28 43 25.18	0.35	−0.04	7.870	0.505	a, e, f, j, m, n, p.
4[illegible]	5.4	31 24	3.1	0 46 6.10	0.3	−0.025	7.560	0.420	a, c, d, l, m.
462	5.3	34 53	4.2	43 8 54.82	0.3	−0.065	7.278	0.577	a, c, e, l, n, r.
471	5.2	42 18	4.0	37 17 15.87	0.25	+0.045	6.669	0.556	a, c, l, m, p, r.
474	3.3	43 42	3.3	6 45 47.65	0.25	+0.02	6.554	0.447	a, c, f, j, p, q, t, x.
477	5.0	45 4	4.0	36 30 39.87	0.2	−0.015	6.441	0.555	a, c, f, l, m, p, r, s.
478	4.0	45 11	3.2	5 24 39.79	0.15	+0.002	6.431	0.443	a, c, j, q, u, x.
484	3.9	48 22	3.1	2 15 17.26	0.15	−0.007	6.167	0.435	a, c, k, t, u, x.
496	4.0	54 35	4.2	40 54 35.70	0.15	−0.006	5.646	0.587	a, c, e, i, j, m, q, r, t, u.
501	4.7	58 7	3.4	15 14 44.93	0.25	−0.04	5.350	0.484	a, c, e, f, i, j, l, m, p.
502	3.3	4 58 35	4.2	41 4 50.12	0.1	−0.061	5.309	0.592	a, c, e, i, k–m, q–u, +
504	5.1	5 0 46	3.5	18 29 32.73	0.2	+0.02	5.126	0.496	a, c, f, j–n, p. v.
506	5.5	1 13	3.7	24 6 53.23	0.35	−0.02	5.087	0.517	a, c, i–m, p, r.
509	6.0	2 39	3.8	27 53 10.38	0.45	----	4.965	0.532	d, q.
515	4.9	5 42	4.1	38 20 58.23	0.15	−0.071	4.707	0.583	a, c, e, l, m, p–s, u, +
516	4.5	7 23	3.1	2 43 33.22	0.35	−0.01	4.564	0.447	a, l, x.
519	5.9	8 44	3.2	5 1 27.19	0.5	----	4.448	0.455	q.
524	5.0	11 12	4.2	39 59 51.15	0.2	−0.65	4.239	0.595	a, c, e, f, i, k–m, r.
534	5.0	16 54	3.2	3 26 5.45	0.2	0.00	3.749	0.453	a, i–l, n, p, q, x.
541	5.3	20 9	4.0	34 22 42.33	0.25	−0.045	3.468	0.572	a, k, m, q.
551	4.6	25 35	3.5	18 30 33.30	0.2	−0.005	2.999	0.508	a, c, i, k–m, p.
557	5.4	28 33	3.7	23 57 48.02	0.25	−0.025	2.743	0.530	a, k, m, p, r.
558	4.4	28 37	3.3	9 24 43.66	0.2	−0.002	2.737	0.477	a, c, k, q, u, x.
561	4.4	30 42	3.3	9 13 42.36	0.25	−0.305	2.557	0.477	a–c, f, i, k, x.
567	4.5	5 33 13	+3.2	+ 4 3 23.72	±0.45	+0.02	+ 2.338	−0.460	a, j.

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual preces-sion.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
573	4.6	5 41 21	+4.2	+39 8 28.89	±0.2	—0.02	+1.631	—0.605	c, e, l, m, r.
575	5.3	41 56	3.2	6 24 48.78	0.3	—0.01	1.579	0.469	a, c, l, n.
578	5.2	43 20	4.1	+37 16 18.55	0.2	—0.04	1.457	0.595	a, c, l, m, p, r.
(2640)	5.3	45 55	2.9	— 7 32 57.75	0.25	—0.01	1.232	0.422	a, l, w, x, z.
591	6.0	50 1	3.7	+24 13 54.53	1.3	----	0.874	0.536	i.
600	6.0	54 2	4.7	49 54 9.11	0.4	—0.06	0.523	0.680	a, c, e, r.
602	5.1	56 46	3.6	19 41 29.30	0.25	—0.02	0.282	0.518	a, c, f, k–m, p.
604	4.3	5 57 15	3.6	23 16 6.25	0.15	—0.105	+0.241	0.532	a, f, i–n, p, r, v.
509	4.4	6 1 7	3.4	14 46 51.97	0.15	—0.013	—0.098	0.500	a, c, f, i, k–n, p, q, u, x, +
615	5.6	5 20	3.6	19 48 52.56	0.3	—0.015	0.467	0.519	a, i, m, n.
616	4.2	5 31	3.4	14 14 0.43	0.3	—0.025	0.482	0.497	a, c, l, m.
620	3.5+	8 3	3.6	22 32 19.11	0.1	—0.003	0.704	0.528	a, c, e, f, i–n, p–r, t, u, x, +
621	4.5	8 11	3.8	+29 32 18.94	0.25	—0.265	0.715	0.558	a, c, e, f, i–m, p, r.
(2893)	6.9 z	12 43	2.4	—26 53 33.18	0.35	----	1.113	0.348	o, p, x, z.
628	5.9	15 21	6.9	+70 35 41.20	1.2	----	1.342	1.00	e.
630	3.2	16 7	3.6	22 34 14.42	0.1	—0.101	1.409	0.527	a, c, e, f, i–n, p–r, t, u, x, y, +
634	5.2	21 26	3.1	0 21 58.83	0.3	0.00	1.872	0.447	a, c, l, n.
637	4.0	22 15	3.6	20 16 57.97	0.15	—0.01	1.944	0.517	a, c, f, i–m, p, q, x.
639	6.0	25 5	3.9	32 32 3.01	0.35	—0.03	2.190	0.568	a, c, i, l–n, p.
640	4.9	25 30	3.3	11 37 18.72	0.35	----	2.227	0.484	d, n, q.
647	5.2	31 16	4.3	+42 35 13.24	0.25	—0.065	2.727	0.619	a, c–e, l, m, r.
(3131)	5.8	34 54	2.5	—23 35 37.43	0.35	----	3.042	0.358	p, x, z.
652	5.0	35 50	3.5	+17 45 18.02	0.3	—0.085	3.122	0.503	a, c, i, l–n.
654	3.2	36 59	3.7	25 14 31.34	0.15	—0.005	3.221	0.531	a, c, e, f, i–m, p–r, t, u, +
659	4.9	39 10	6.3	67 41 41.99	0.25	+0.02	3.411	0.904	a, c, e, i, j, m, p.
662	5.6	40 23	3.3	8 42 22.24	0.3	+0.01	3.515	0.469	a, c, l, n.
672	3.7	45 20	4.0	34 5 47.43	0.15	—0.032	3.942	0.565	a, c, i, j, m, p–u, +
673	4.5	47 29	5.2	+58 34 10.26	0.1	—0.123	4.126	0.743	a, c, e, f, i, l, m, q–s, u, +
(3294)	5.2	50 56	2.7	—13 53 52.72	0.2	+0.005	4.420	0.389	a, j–m, w, x, z.
677	5.9	6 53 46	3.5	+16 14 3.76	0.3	+0.01	4.662	0.488	a, c. l, n.
686	5.6	7 1 53	3.4	16 6 37.29	0.25	—0.10	5.348	0.482	a, c. k, m.
689	5.5	4 23	3.7	27 2 28.70	0.25	—0.04	5.560	0.521	a, c, i, l–n, r.
696	5.4	6 53	3.4	16 20 59.55	0.3	—0.035	5.769	0.479	a, c, e, f, i–n, p, x.
699	4.8	9 57	4.6	+49 39 53.50	0.7	----	6.025	0.636	b–e, h.
(3531)	6.6 z	12 1	2.9	— 6 28 43.21	0.35	----	6.199	0.403	x, z.
704	{ 6.4 e	13 37	4.9	+55 29 44.86	0.45	—0.04	6.332	0.679	c, e, l, m.
	{ 5.6 e	13 39	4.9	55 29 35.12	0.15	—0.028	6.333	0.679	c, e, l, m, q. r, u, +
705	5.3	14 30	4.0	36 58 19.41	0.02	—0.02	6.403	0.555	a, c, e, l, m, p, r, s.
706	5.0	15 17	3.6	20 39 21.89	0.25	—0.015	6.470	0.488	a, c, l–n, r.
707	5.3	16 19	4.2	40 53 20.36	0.25	—0.005	6.555	0.572	a, c, e, m, q, r.
715	6.3	21 2	3.6	21 40 32.03	0.2	—0.105	6.943	0.486	a, c, i, k–n, p, r.
719	5.3	21 57	3.2	+ 7 10 17.50	0.3	—0.03	7.020	0.439	a, g, l, n.
(3653)	5.8	22 33	2.8	—11 19 42.10	0.35	0.00	7.068	0.382	f, p, w, x, z.
725	5.1	26 14	3.1	+ 2 9 11.68	0.3	+0.01	7.368	0.421	a, c, g, l, n.
726	5.0	7 27 10	+3.4	+16 4 7.70	±0.25	—0.015	—7.444	+0.462	a, c, e, i–n, p.

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
729	5.8	7 28 20	+4.4	+46 25 41.89	±0.45	----	−7.539	−0.591	b, c, e, h, r.
730	4.2	28 58	3.7	+27 8 45.52	0.2	−0.105	7.590	0.498	a, c, e, f, i, k–m, p, r.
(3745)	5.1	31 40	3.0	−3 51 33.67	0.25	+0.031	7.809	0.399	c, l, n, w, x, z.
733	6.0	32 38	4.1	+38 36 7.61	0.7	----	7.887	0.545	e, p.
735	5.2	32 57	3.5	17 55 51.63	0.3	+0.01	7.913	0.463	a, c, i, l, m, p.
737	0.5	33 23	3.1	5 30 50.14*	0.1	−1.027*	7.948	0.424	a–c, e, f, i–n, p, q, s–w, x, y, +
742	3.6	37 38	3.6	24 40 4.98	0.15	−0.055	8.286	0.480	a, c, e, f, i–m, p, r, t, u, +
745	5.1	39 35	3.5	18 47 6.20	0.25	−0.04	8.443	0.459	a, c, e, i, k–m, p.
747	5.4	40 13	3.9	33 41 31.77	0.2	−0.006	8.492	0.510	a, c, l, m, p–r, u, +
751	5.8	46 29	4.4	47 51 23.06	0.2	−0.020	8.985	0.570	c, e, i, j, q, r, u.
752	4.9	46 35	3.7	27 3 26.74	0.2	−0.025	8.993	0.477	a, c, e, f, i–k, m, p–r, v.
755	5.9	50 35	3.4	16 5 29.10	0.25	−0.035	9.305	0.438	a, c, i, k–m, p.
756	6.2	51 8	3.3	+8 56 34.02	0.5	−0.01	9.348	0.418	c, g, n.
(4018)	5.1	54 5	3.0	−3 22 19.87	0.2	+0.01	9.575	0.381	c, l, n, w–z.
764	5.0	56 35	3.7	+28 6 37.26	0.15	−0.039	9.766	0.468	a, c, f, i–n, q, r, u, v, x, y, +
765	5.1	58 47	3.4	13 26 21.49	0.25	−0.07	9.935	0.421	a, c, i, j, l, n, p.
766	6.2	59 37	3.6	+22 57 26.50	0.2	−0.01	9.997	0.448	a, c, i, l–n, p, r.
(4100)	7½z	7 59 48	2.5	−25 22 46.23	0.35	----	10.011	0.315	p, x, z.
768	5.2	8 1 7	3.5	+21 54 32.62	0.2	−0.065	10.111	0.442	a, c, k–n, p, r.
769	5.5	1 34	6.1	68 48 19.25	0.3	+0.005	10.145	0.761	a, c, e, i, k–m, p, q.
770	5.9	4 50	4.8	56 47 23.17	0.4	−0.035	10.390	0.600	a, c, e, i, p, r.
772	5.1	5 44	3.4	17 59 16.69	0.2	−0.105	10.458	0.425	a, c, e, f, i–n, p, q.
	6.0	5.44	3.4	+17 59 12.07	0.25	−0.105	10.458	0.425	a, c, e, f, i–m, p.
(4159)	4.6	5 58	2.8	−12 35 32.52	0.3	+0.015	10.475	0.346	a, c, g, l, w, x.
773	5.6	6 9	3.7	+29 59 39.85	0.25	−0.01	10.489	0.461	a, c, i, m, r, v.
774	5.4	8 27	5.0	+59 54 58.45	0.2	0.00	10.659	0.620	a, c, e, i, m, n, r.
(4240)	6.6z	12 12	2.8	−15 56 8.37	0.25	+0.01	10.937	0.332	a, c, l, w, x, z.
779	5.7	13 49	3.6	+24 22 37.99	0.25	−0.04	11.055	0.432	a, c, i–n, p, v.
781	5.8	15 15	4.6	+53 34 57.95	0.35	−0.095	11.160	0.554	a, c, e, i, k, r.
(4298)	6.5z	17 28	2.8	−12 41 31.17	0.25	−0.025	11.320	0.335	a, c, l, w, x, z.
783	5.8	19 6	5.8	+67 40 4.18	0.3	−0.005	11.438	0.689	c, e, k, m.
785	6.2	19 43	4.2	+46 1 58.36	0.5	−0.38	11.482	0.500	e, f, o.
(4335)	5.5	20 11	2.6	−23 40 49.38	0.35	0.00	11.515	0.305	p, v–x, z.
(4342)	6.0z	20 49	3.0	−3 36 59.47	0.2	−0.05	11.560	0.353	a, c, g, l, n, w, x, z.
790	5.9	21 55	3.6	+24 31 8.47	0.3	−0.065	11.639	0.420	a, c, j, m.
792	5.8	24 50	3.6	24 27 40.63	0.2	−0.065	11.845	0.416	a, c, f, j–n, p, r, x.
793	5.8	25 9	3.4	18 28 32.33	0.25	−0.06	11.869	0.400	a, c, e, i–n, p, v.
	6.1	26 7	3.9	36 49 7.73	0.25	+0.005	11.937	0.451	c, i, m, r.
795	5.7	27 28	3.9	36 48 23.26	0.3	−0.03	12.031	0.449	c, i, m.
797	6.1p	29 51	3.2	7 0 49.09	0.35	−0.14	12.197	0.367	a, c, n, p.
	7.1p	29 51	3.2	7 0 58.12	0.4	−0.14	12.198	9.367	n, p.
800	4.1	31 40	3.2	6 5 50.20	0.25	0.00	12.324	0.362	a, c, i, j, p, q, x.
801	4.4	32 51	3.1	3 44 14.85	0.3	−0.02	12.405	0.355	a, c, k, n, x.
803	4.8	36 45	3.5	21 52 27.16	0.2	−0.035	12.671	9.390	a, c, f, i–n, p–r, v, x.
805	5.6	8 36 59	+3.3	+13 5 7.47	±0.25	−0.005	−12.686	−0.370	a, c, k–n.

* Proper motion variable; apply special correction given in "Jahrbuch" or "Ephemeris."

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
805	4.2	8 37 19	+3.1	+ 3 48 13.34	±0.35	+0.005	−12.709	−0.349	a, c, k, x.
806	4.3	38 16	3.4	18 34 8.62	0.15	−0.226	12.774	0.380	a, c, e, f, i–m, p, q, t–v, +
808	5.5	38 37	3.3	10 29 25.18	0.3	−0.01	12.797	0.362	a, c, l, n.
809	4.2	39 52	3.6	+29 10 21.32	0.15	−0.033	12.880	0.403	a, c, k–m, r, t, u, +
811	5.1	41 31	3.0	− 1 29 1.13	0.4	0.00	12.992	0.333	a, c, g, w, x, z.
814	5.2	44 22	4.1	+44 8 47.06	0.2	+0.04	13.180	0.441	a, c, e, i, k, l, p–r.
815	5.7	45 36	3.7	32 53 48.71	0.25	+0.02	13.262	0.403	a, c, l–n, r.
	6.4 f	45 41	3.6	28 40 57.70	0.25	+0.01	13.267	0.392	a, c, f, l–n.
816	6.2	45 53	3.6	28 45 42.06	0.2	−0.245	13.272	0.392	a, c, f, k, n, r.
818	5.5	47 21	3.7	31 0 23.92	0.15	−0.021	13.375	0.394	a, c, g, l, m, q, r, u.
819	5.2	48 54	3.6	28 21 28.61	0.25	−0.045	13.476	0.386	a, c, i–l, n, p, r.
820	5.8	49 11	3.9	40 38 1.31	0.4	−0.035	13.495	0.419	e, r.
822	5.7	49 45	3.3	12 3 25.81	0.2	−0.015	13.532	0.349	a, c, f, i, k–n, p.
825	5.2	50 57	3.4	15 45 19.77	0.5	+0.02	13.610	0.355	a, c, i.
829	4.3	52 18	3.3	12 17 40.51	0.15	−0.022	13.696	0.345	a, c, e, f, i–n, p, q, t, u, +
828	5.0	52 21	5.5	+68 4 8.35	0.15	+0.016	13.699	0.584	a, c, e, l, m, p, u.
(4786)	6.8 z	55 54	2.6	−23 42 43.85	0.35	----	13.924	0.273	p, x, z.
835	5.3	58 28	5.4	+67 19 32.98	0.25	−0.5	14.084	0.550	a, c, e, i–k, m, q.
836	4.7	8 59 21	3.8	38 54 12.12	0.3	−0.005	14.139	0.393	a, c, e, i, k, m, r.
837	5.6	9 0 1	3.2	5 32 35.36	0.3	0.00	14.182	0.322	a, c, g, n.
839	4.4	0 54	4.3	52 3 35.93	0.25	−0.035	14.235	0.438	a, c, e, f, k, r.
840	5.4	1 13	3.6	+30 6 28.37	0.2	+0.005	14.255	0.367	c, l–n, p, r.
(4888)	6.1	6 51	3.0	− 6 38 48.63	0.25	+0.045	14.598	0.291	a, c, l, n, w, x, z.
848	5.6	7 27	4.5	+57 12 32.61	0.25	−0.035	14.634	0.448	a, c, e, i, j, r.
849	4.9	8 3	4.4	54 29 16.28	0.25	+0.07	14.670	0.432	a, c, e, i, k, p, r.
851	5.6	9 0	3.3	+15 24 35.14	0.25	0.00	14.726	0.324	a. c, f, k–m, p.
(4913)	8 z	9 21	2.9	− 8 17 23.65	0.35	----	14.747	0.285	x, z.
(4920)	8 z	10 1	2.9	− 8 16 24.26	0.35	----	14.786	0.284	w, x, z.
854	3.4	14 10	3.7	+34 52 11.13	0.1	+0.027	15.029	0.352	a, c, f, l, m, p–u, +
(4969)	5.9	14 13	2.8	−15 21 23.16	0.35	−0.07	15.031	0.267	o, x, z.
855	4.6	18 4	3.5	+26 40 5.47	0.2	−0.035	15.253	0.328	a, c, i, k, m, r.
857	5.6	21 15	4.0	+46 5 44.95	0.25	−0.145	15.432	0.367	c, e, f, i, p, r.
(5055)	2.0	22 2	2.9	− 8 10 8.98	0.1	+0.052	15.475	0.268	a, b, e, f, i–n, p, q, s–v, x–z, +
(5059)	5.3	22 11	3.0	− 5 34 41.27	0.25	−0.075	15.484	0.271	e, k, o, x, z.
860	6.0	22 28	3.2	+ 8 40 51.14	0.3	−0.02	15.500	0.292	a, f, l, n.
864	3.2	25 18	4.0	52 11 29.83	0.1	−0.564	15.657	0.374	a–c, e, f, i–n, p–u, +
866	5.2	25 51	3.2	11 47 59.13	0.2	−0.08	15.686	0.289	a, c, e, i–n, p, x.
867	5.4	25 54	3.2	+10 12 49.17	0.25	0.00	15.688	0.287	a, c, f, i, k, l, n, p.
868	4.6	26 13	3.1	− 0 41 12.97	0.25	−0.015	15.706	0.272	a, c, g, l, w, x, z.
871	5.0	28 1	3.8	+40 7 20.85	0.4	0.00	15.805	0.334	a, c, e, r.
873	5.7	30 1	3.6	31 40 2.13	0.35	−0.075	15.910	0.313	c, g, l, n.
875	5.3	31 18	3.8	+40 44 47.66	0.25	+0.005	15.979	0.327	a, c, e, k, l, q, r,
879	4.2	34 5	3.1	− 0 37 49.26	0.2	−0.065	16.124	0.260	a, d, f, k, n, w, x, z.
(5225)	4.9	34 53	2.9	−13 49 11.29	0.25	+0.01	16.166	0.242	a, c. k, w, x, z.
880	5.5	9 35 0	+3.7	+40 16 20.19	±0.3	−0.06	−16.172	−0.319	a, c, e, l, n.

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
881	3.8	9 35 7	+3.2	+10 24 21.50	±0.15	−0.018	−16.178	−0.271	a, c, e, f, i–n, p, q, t–v, x.
882	5.9	36 56	3.5	30 29 36.00	0.3	−0.10	16.272	0.296	c, f, l, m.
883	5.7	37 35	3.3	14 32 17.51	0.2	0.00	16.305	0.273	a, c, f, i, i, k, m, n, p, q, v.
884	5.6	38 31	4.3	57 38 46.91	0.2	+0.035	16.353	0.359	a, c, e, l, m, r.
885	3.1	39 26	3.4	24 17 38.76	0.1	−0.008	16.399	0.281	a–c, e, f, i–n, p–v, x, y, +
887	5.7	40 34	3.1	2 18 26.88	0.5	−0.04	16.455	0.253	c, g, n, p.
888	5.3	41 18	3.9	+46 32 49.30	0.25	−0.09	16.492	0.318	a, c, e, f, i, l, p, r.
(5293)	6.6 z	42 36	3.0	− 6 43 17.00	0.2	−0.005	16.556	0.239	c, l, n, w, x, z.
893	4.1	46 20	3.4	+26 32 19.34	0.15	−0.045	16.738	0.271	a, c, e, f, i–n, p–r, t, u, x.
894	6.0	46 23	3.1	+ 2 58 51.36	0.3	+0.11	16.741	0.244	a, c, f, k, n.
(5336)	5.3	46 55	3.0	− 7 34 24.16	0.25	−0.03	16.766	0.231	a, c, g, l, n, w, x, z.
(5345)	7.2	47 48	3.0	− 9 22 19.55	0.35	−0.04	16.809	0.228	x, z.
895	5.3	48 20	3.9	+50 21 9.94	0.25	+0.015	16.835	0.310	a, c, e, l, r.
896	5.2	50 46	3.7	41 35 35.96	0.15	−0.006	16.948	0.283	a, c, e, i, k, m, p–r, u.
898	5.3	52 9	3.2	12 59 0.31	0.25	−0.02	17.013	0.244	a, c, f, i–n, p, v.
899	5.9	53 6	3.5	30 11 9.46	0.35	−0.065	17.056	0.262	a, c, g, l, m, p, r.
900	5.0	54 15	3.2	8 35 9.75	0.15	−0.011	17.109	0.236	a, c, e, f, i–n, p, q, u, v, x, +
901	6.0	9 54 30	3.5	32 28 44.08	0.2	−0.44	17.211	0.262	a, c, f, k–m, r.
903	4.6	10 0 46	3.6	35 47 42.25	0.2	+0.01	17.400	0.252	a, c, f, i–m, p, r.
905	4.6	1 54	3.2	10 33 4.55	0.25	−0.04	17.450	0.224	a, c, g, i, k–m, p.
906	4.5	2 9	3.1	0 10 49.80	0.2	+0.005	17.460	0.214	a, c, k, m, s, x.
907	1.4	2 21	3.2	12 31 9.15	0.1	+0.018	17.469	0.224	a, e–g, i–n, p–v, x, y, +
910	5.4	9 49	3.4	29 52 22.66	0.25	−0.03	17.781	0.226	a, c, f, l, n, p, r.
911	3.6	10 17	3.6	43 28 41.29	0.15	−0.058	17.799	0.240	a, c, e, i, j, l, m, p–u, +
912	5.8	10 17	3.3	24 3 51.34	0.25	+0.025	17.800	0.218	a, c, f, l, n, r.
	3.8	10 24	3.3	23 58 48.68	0.15	+0.017	17.804	0.218	a, c, k, m, n, r, t, u.
913	5.9	10 37	3.2	14 17 29.03	0.25	−0.025	17.812	0.210	a, c, e, f, j, k, m, n.
917	5.0	13 35	3.3	20 2 38.57	0.25	−0.215	17.930	0.209	a, c, f, i, n, r.
918	2.5	13 44	3.3	20 24 46.07	0.15	−0.14	17.937	0.208	a, c, e, f, i–n, p–r, t, v, x, y.
919	3.1	15 36	3.6	42 4 2.85	0.15	+0.034	18.008	0.225	a, c, e, f, i–m, q–u, +
921	5.9	16 36	3.5	34 28 41.72	0.35	−0.01	18.047	0.216	a, c, d, g, l.
924	6.2	19 18	3.2	+ 9 21 31.90	0.35	−0.04	18.149	0.191	a, c, d, g, i, k, l, n, p.
(5697)	4.1	20 38	2.9	−16 15 34.83	0.2	−0.061	18.198	0.171	a, c, f, j–m, p, q, t–x, z, +
927	4.9	23 23	3.9	+56 33 34.75	0.15	−0.032	18.298	0.227	a, c, e, f, i, k, m, p–s, u, +
928	5.2	23 44	3.1	− 2 9 39.23	0.25	−0.005	18.310	0.174	a, c, i, n, w, x, z.
929	4.9	24 31	3.1	− 0 3 27.80	0.25	−0.015	18.338	0.174	a, c, k, l, n, p, x.
932	5.1	26 38	3.5	+41 0 23.65	0.35	−0.015	18.411	0.193	a, c, e, h, k, n, p, r.
933	4.0	26 52	3.2	+ 9 53 16.35	0.15	+0.011	18.420	0.196	a, c, e, f, i–n, p, q, t–v, x, y, +
(5806)	6.1	30 45	2.8	−26 5 17.16	0.35	----	18.552	0.149	p, x, z.
(5825)	5.2	31 56	2.8	26 49 39.02	0.4	0.00	18.590	0.147	d, p, v–x, z.
(5827)	5.4	31 58	3.0	−12 47 49.42	0.5	0.00	18.592	0.154	a, d, g, h, p, w, x.
937	4.8	32 22	3.4	+32 33 46.70	0.25	+0.015	18.605	0.178	a, c, k, m, p, r.
940	5.0	34 14	4.2	66 18 28.83	0.2	−0.075	18.665	0.219	a, c, e, f, i, k–m, p.
945	5.1	37 16	3.3	23 46 46.96	0.15	+0.026	18.761	0.162	a, c, l, m, p–r, u.
946	5.4	39 35	3.4	31 16 38.19	0.15	−0.017	18.831	0.161	a, c, k–m, p–r, u, +
947	5.7	10 40 19	+3.2	+19 29 13.42	±0.35	−0.035	18.854	−0.154	a, c, f, i, q.

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual preces-sion.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
949	5.3	10 43 19	+3.2	+11 8 34.53	±0.15	−0.020	−18.941	−0.144	a, c, f, g, i–n, p, q, u, v, x, y, +
950	5.7	44 17	3.8	59 55 11.41	0.2	−0.05	18.969	0.175	a, c, e, i, j, m, p, r.
955	4.9	47 28	3.5	+43 47 28.58	0.2	−0.03	19.058	0.151	a, c, e, i, k–n, q, r.
(6021)	5.2	47 58	2.9	−19 31 49.30	0.25	−0.025	19.071	0.124	a, c, f, l, o, p, v–x, z, +
956	5.9	47 59	3.1	− 1 31 43.89	0.35	+0.02	19.071	0.131	a, d, h, n, p, w, x, z.
957	5.2	49 29	3.3	+34 6 35.12	0.25	−0.05	19.112	0.142	a, c, f, k, l, n, p, r.
958	4.3	49 30	3.3	25 21 8.17	0.2	−0.005	19.112	0.138	a, c, k, m, n, p–r.
961	6.3	53 14	3.4	+36 41 59.00	0.45	−0.065	19.208	0.134	a, c, p, q.
(6072)	4.1	54 16	2.9	−17 41 49.07	0.25	+0.15	19.235	0.114	a, c, f, j, o, q, t, v–x.
963	5.4	54 30	3.4	+39 49 7.95	0.25	−0.02	19.241	0.134	a, c, e, l, r.
964	5.0	54 43	3.1	4 13 26.47	0.25	−0.01	19.245	0.119	a, c, e, f, i–n, p, x.
965	5.1	54 53	3.1	6 42 30.04	0.3	−0.03	19.249	0.120	a, c, f, i, k–n, p, v.
966	2.6	55 1	3.7	56 59 16.54	0.1	+0.041	19.250	0.142	a, c, e, f, i, j, m, p–u, +
970	4.7	10 59 11	3.1	7 56 48.59	0.15	−0.022	19.351	0.112	a, c, e, f, i–n, p, q, u, v, x, y, +
971	5.7	11 1 8	3.1	2 34 8.09	0.2	−0.07	19.396	0.107	a, c, f, g, i, k, l, n, p, q.
973	6.1	3 6	3.3	36 55 17.60	0.35	−0.065	19.438	0.112	a, c, g, l, m, p, r.
976	2.8	8 6	3.2	21 8 33.95	0.1	−0.115	19.541	0.097	a–c, e, f, i–n, p–u, x, y, +
977	3.5	9 19	3.2	16 2 49.85	0.15	−0.063	19.545	0.096	a, c, f, j, k, m, t, u.
978	4.9	9 12	3.2	23 42 40.57	0.25	−0.005	19.564	0.096	a, c, k, p, r.
983	3.8	12 23	3.3	33 42 38.88	0.15	+0.052	19.621	0.091	a, c, j, m, q, r, t, u, +
984	4.8	12 58	3.3	38 48 18.53	0.3	−0.08	19.632	0.090	a, c, e, i, k, n, r, x.
985	4.1	15 19	3.1	6 38 54.65	0.15	0.00	19.674	0.080	a, c, e, f, i–n, p, q, t–v, x, +
988	4.0	18 2	3.1	11 9 5.94	0.15	−0.063	19.718	0.075	a, c, e, f, i–h, k, m, n, p, q, t–v.
991	5.1	22 8	3.1	+ 3 28 42.80	0.2	−0.01	19.780	0.066	a, c, e, f, i–n, p, q, v, x.
(6388)	5.7	24 2	3.0	−23 50 31.51	0.35	----	19.807	0.060	o, x, z.
994	4.1	24 41	3.6	+69 57 16.58	0.15	−0.027	19.816	0.075	a, c, e, i–m, p, q, t, u, +
995	5.6	25 56	3.4	+61 42 28.99	0.3	−0.09	19.832	0.058	a, e, h, m, r.
(6415)	6.6	26 47	3.0	−26 7 26.21	0.35	----	19.843	0.055	x, z.
997	5.8	28 51	3.3	+55 24 34.43	0.4	0.00	19.869	0.053	a, c, e, h, r.
998	5.5	29 25	3.6	69 57 5.60	0.2	−0.125	19.876	0.053	a, c, e, f, k–m, p.
999	5.8	30 21	3.2	+28 24 20.16	0.25	−0.02	19.886	0.053	a, c, k, m, p, r.
1000	4.5	31 10	3.1	− 0 11 59.63	0.1	+0.047	19.895	0.049	a, c, e, f, i–n, p, q, u, v, x–z, +
1002	5.5	32 19	3.2	+44 15 5.97	0.3	−0.065	19.908	0.050	a, c, e, f, i, n, p, r.
(6487)	5.6	32 56	3.0	−12 34 47.48	0.25	+0.125	19.913	0.044	a, c, f, l, p, w, x, z.
1004	5.8	35 6	3.2	+34 50 23.70	0.2	−0.38	19.935	0.043	a, c, f, k–m, p, r.
1005	5.7	35 42	3.1	32 22 17.84	0.3	+0.02	19.941	0.042	a, c, f, l, n.
1007	4.9	39 28	3.1	8 53 10.28	0.25	−0.02	19.973	0.033	a, c, f, j–n, v.
1008	4.2	40 3	3.1	7 9 45.76	0.2	−0.17	19.977	0.032	a, c, e, f, i–n, p, v.
1011	5.2	42 7	3.1	8 52 24.13	0.3	0.00	19.992	0.028	a, c, j, k, m, n, p.
1014	5.6	43 49	3.1	35 33 33.87	0.3	−0.02	20.003	0.026	a, c, l, n, r.
1015	3.7	44 49	3.1	2 24 5.34	0.1	−0.262	20.010	0.022	a, c, e, f, i–n, p, q, s–v, x, +
1017	5.6	49 15	3.1	9 4 19.34	0.3	0.00	20.031	0.014	a, c, g, l, n.
1018	5.4	49 52	3.1	16 16 32.28	0.25	+0.01	20.034	0.013	a, l, m.
	7:	52 26	3.1	4 6 40.78	0.35	0.00	20.042	0.008	a, c, l–n.
1020	6.0	11 53 29	+3.1	+33 47 46.61	±0.45	----	−20.045	−0.005	p, q.

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
1021	5.2	11 54 10	+3.1	+ 4 17 4.63	±0.2	—0.01	—20.047	—0.004	a, c, e, f, i–n, p, q, v, x.
1022	4.4	55 5	3.1	7 14 39.88	0.2	—0.03	20.049	0.002	a, c, e, f, i–n, p, x.
1023	5.7	55 53	3.1	36 40 24.85	0.7	—0.09	20.050	—0.001	d, p.
1025	5.7	58 29	3.1	22 5 18.11	0.25	0.005	20.053	+0.003	a, c, l, p, r.
1027	4.3	59 27	3.1	9 21 38.36	0.15	+0.049	20.053	0.006	a, c, e, f, i–n, p, q, t–v, x, +
1029	6.2	11 59 57	3.1	+63 33 52.20	0.35	—0.075	20.053	0.007	a, d, e, h, i, k–m.
(6756)	6.7 z	12 1 14	3.1	—23 8 17.09	0.35	+0.10	20.053	0.010	p, x, z.
1030	6.3	4 46	3.1	+17 26 17.36	0.25	+0.005	20.049	0.016	c, g, l, m, +
1031	5.7	5 2	3.1	27 54 37.14	0.35	—0.04	20.048	0.017	g, l–n, p.
1032	5.9	6 7	3.1	26 29 59.31	0.25	—0.03	20.046	0.019	a, c, g, j, k, m, r.
1033	5.6	6 34	3.1	21 10 16.72	0.25	—0.02	20.045	0.019	a, c, g, l, n, r.
1037	5.1	10 16	3.1	15 31 41.51	0.25	—0.02	20.033	0.027	a, c, k, m, n, +
1045	5.2	14 37	3.1	3 56 31.52	0.25	—0.06	20.013	0.036	a, c, e, f, i–k, m, p, v.
1048	4.9	15 0	3.0	+18 25 1.93	0.25	+0.075	20.011	0.036	a, c, k, m, +
(6885)	5.9	17 28	3.1	—24 12 48.18	0.2	—0.02	19.995	0.043	g, l, o, p, w, x, z.
(6903)	6.5	19 23	3.1	— 27 7 21.92	0.35	-----	19.982	0.046	p, x, z.
1053	6.2	19 34	3.0	+24 33 12.43	0.25	—0.005	19.980	0.045	c, f, l–n, p, r, +
1054	6.3	19 50	2.8	64 25 43.13	0.3	—0.01	19.979	0.043	c, e, m, p.
1055	5.3	20 17	3.0	39 38 44.09	0.2	—0.026	19.974	0.046	a, c, e, i, j, n, q, r, u.
1059	5.9	23 12	2.9	56 20 18.38	0.25	—0.02	19.951	0.048	a, c, e, i, p, r, +
1061	5.5	23 48	3.0	+24 44 1.67	0.3	0.00	19.946	0.052	a, c, i, r, +
(6943)	3.1	24 1	3.1	— 15 53 10.74	0.15	—1.146	19.943	0.055	a, c, e, f, j–m, p, q, u, v, x, z.
1062	5.7	24 3	3.0	+21 31 19.26	0.15	—0.017	19.942	0.054	a, c, f, l, n, p–r, u, +
1065	5.5	25 22	3.0	25 11 30.32	0.2	—0.02	19.931	0.056	a, c, d, g, l–n, r, +
1069	4.9	29 13	3.0	23 15 6.09	0.25	+0.01	19.890	0.063	a, c, f, k–n, r, +
1072	5.6	31 18	3.0	17 42 43.70	0.25	—0.035	19.867	0.067	a, c, g, l–n.
1073	6.1	32 37	3.1	2 28 36.58	0.35	—0.015	19.850	0.070	a, c, m, n, p.
1076	6.3	33 47	2.9	+36 34 24.06	0.8	-----	19.836	0.070	a, d, p, +
1077	2.8	35 56	3.0	— 0 49 46.41	0.1	+0.015	19.807	0.077	a, c, e, f, i–n, p, q, s–v, x–z, +
1082	5.3	41 0	3.0	+17 11 42.17	0.5	+0.000	19.734	0.085	a, c, k.
1085	5.7	43 14	3.0	14 44 22.87	0.25	—0.025	19.697	0.089	a, c, g, k, l, n, p, v, +
1086	6.4	43 17	3.0	25 27 37.12	0.45	-----	19.696	0.088	d, q.
1089	5.9	44 49	2.9	38 7 54.07	0.4	0.00	19.671	0.089	a, c, e, h, i, m, p, r, +
1091	5.1	47 44	3.0	21 51 33.90	0.25	—0.03	10.620	0.096	a, c, i–k, m, r.
1096	3.7	49 55	3.0	4 0 42.42	0.15	—0.047	19.579	0.104	a, c, e–g, i–n, p, c–v, x.
1097	5.7	50 43	2.8	38 55 30.41	0.25	+0.066	19.564	0.098	e, f, h–m, p.
	3.1	50 44	2.8	38 55 43.81	0.1	+0.066	19.564	0.098	a, c, e–g, i–n, p–u, x, y, +
1099	5.0	53 20	3.0	18 1 8.13	0.25	+0.05	19.513	0.107	a, c, k, m, q.
1100	5.1	54 52	2.9	31 23 40.76	0.2	—0.01	19.482	0.107	a, c, k–n, p, r, +
1104	3.0	12 56 33	3.0	11 34 0.09	0.15	+0.029	19.446	0.114	a, c, f, g, j–n, p, q, t, u, x, +
1109	6.1	13 0 51	2.9	21 45 35.24	0.25	—0.055	19.350	0.119	a, c, k, m, r, +
1110	6.1	0 53	2.9	23 13 22.16	0.25	—0.03	19.350	0.119	a, c, g, l, n, r, +
1112	4.9	1 45	2.9	28 13 52.61	0.25	—0.09	19.329	0.119	a, c, i, j, l, m, p, r, +
1115	4.4	4 29	2.9	18 7 38.40	0.2	+0.14	19.264	0.127	a, c, f, i, k–n, +
1116	4.4	13 6 36	+2.8	+28 27 4.16	±0.15	+0.897	—19.212	+0.128	a–c, f, i–k, m, p–r, t, u, +

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual preces-sion.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
1117	5.7	13 6 55	+3.0	+12 9 24.92	±0.4	—0.075	—19.206	+0.132	a, c, g, k, n, p.
1121	5.6	11 40	3.0	14 16 14.14	0.3	+0.02	19.081	0.140	a, c, g, l–n, q, +
1127	5.8	15 57	3.1	2 40 53.07	0.45	—0.04	18.962	0.152	a, b, h, n, q.
1128	6.4	18 46	2.7	37 37 26.75	0.3	—0.01	18.881	0.141	c, e, h, m, p, r.
1130	5.9	19 43	2.9	24 26 37.65	0.7	0.00	18.853	0.148	a, c, +
1133	5.2	22 54	2.9	+14 22 56.80	0.2	—0.57	18.755	0.159	a, c, f, k–n, q, +
(7436)	6.6 z	28 19	3.4	—32 43 50.95	0.35	-----	18.583	0.193	x, z.
1138	4.9	28 24	3.0	+ 4 14 23.47	0.45	—0.01	18.581	0.172	a, c, i.
1139	3.5	28 56	3.1	— 0 1 4.04	0.15	+0.056	18.562	0.176	a, c, e, f, i–n, p, q, t–v, x, y, +
1140	5.0	29 45	2.7	+37 45 41.57	0.2	—0.007	18.535	0.156	a, c, e, i, k, m, p–r, u, +
1144	5.0	32 27	2.7	36 52 11.17	0.25	0.00	18.444	0.160	a, b, h, i, j, m, p–r, +
1146	5.6	34 0	3.0	11 19 14.26	0.45	-----	18.390	0.179	a, b, d, g, h, k, n.
1147	5.6	34 28	1.4	71 49 2.72	0.2	+0.011	18.373	0.092	a, e, m, q, u.
1153	5.7	37 23	3.0	+ 4 6 37.04	0.25	—0.06	18.271	0.189	a, c, f, i, k, p.
(7536)	4.4 z	39 16	3.4	—32 28 19.08	0.3	—0.15	18.201	0.216	i, k–m, p, v–z.
1158	5.8	41 28	2.8	+26 16 9.58	0.25	—0.07	18.119	0.181	a, c, i, m, p, r, +
1159	4.5	41 54	2.9	18 1 13.14	0.15	+0.040	18.103	0.188	a, c, f, g, i–m, p, u, x, +
1164	4.1	44 2	2.9	16 21 31.74	0.3	+0.045	18.022	0.192	a, c, j, m, p.
1165	5.0	44 22	2.8	21 49 31.32	0.25	+0.02	18.009	0.189	a, c, f, l, n, p, r, +
1170	4.7	48 8	1.8	65 16 53.71	0.15	—0.014	17.862	0.123	a, c, e, i, k–m, p, q, u.
1172	2.9	49 18	2.9	18 57 52.54	0.1	—0.344	17.815	0.198	a, c, e–g, i–n, p, q, s–u, x, y, +
1175	5.1	51 25	2.7	+28 2 47.33	0.2	—0.055	17.730	0.193	a, c, k–n, q, r, +
(7669)	5.1	52 11	3.4	—24 25 12.89	0.25	—0.045	17.699	9.237	g, l, p, w, x, z.
1176	5.3	53 21	2.8	+22 14 52.34	0.2	—0.05	17.650	0.201	a, c, g, l–n, r, +
(7678)	5.9	53 41	3.4	—24 27 30.32	0.25	—0.105	17.637	0.240	f, l, o, p, w, x, z.
1177	5.9	55 45	3.0	— 9 26 30.24	0.4	-----	17.549	0.216	a, d, n, q.
1180	6.2	58 48	2.2	+51 30 56.12	0.6	0.00	17.419	0.169	c, e, i.
(7718)	3.5	13 59 56	3.4	—26 8 15.01	0.25	—0.14	17.370	0.255	d–f, j, k, p, v–x, z.
1186	5.0	14 6 33	3.0	+ 2 56 29.45	0.4	—0.055	17.074	0.238	a, c, g, k, l, n.
(7771)	4.3	6 52	3.2	— 9 44 50.12	0.15	+0.141	17.059	0.251	a, c, e–g, i–m, p, q, u–x, z.
(7791)	6.5 z	9 37	3.5	—32 42 54.63	0.35	-----	16.931	0.283	p, v, x, z.
1190	5.3	9 58	1.1	+69 57 46.45	0.3	—0.07	16.914	0.093	a, e, f, h, i, k–m.
(7803)	6.5 z	11 43	3.5	—32 41 46.40	0.35	-----	16.832	0.287	p, v, x, z.
1194	4.8	13 13	2.5	+36 1 52.15	0.3	0.00	16.760	0.210	a, c, g, l, m, p, r.
1195	5.2	13 43	3.1	— 1 44 33.42	0.25	—0.07	16.736	0.254	a, c, g, l, n, v, w, z.
1198	5.9	15 9	2.5	+39 18 49.44	0.35	—0.005	16.667	0.207	a, d, e, h, l, r.
1199*	5.0	17 49	3.0	8 57 41.22	0.35	—0.005	16.536	0.249	a, c, g, n.
1200	5.0	18 34	3.0	+ 6 19 58.08	0.45	—0.03	16.498	0.254	a, c, n, p.
1202	4.9	22 23	3.1	— 1 43 15.57	0.15	—0.002	16.305	0.269	a, c, k, n, u, w, z.
(7889)	7½ z	22 33	3.5	—28 36 28.18	0.35	-----	16.299	0.303	o, p, x, z.
(7891)	5.9	22 44	3.2	— 6 23 33.76	0.2	—0.06	16.289	0.275	a, c, d, g, l, m, p, w, x, z.
1203	5.6	24 42	2.1	+50 21 2.85	0.25	—0.055	16.188	0.183	a, c, e, f, k, r, +
1204	3.6	26 58	2.6	30 52 4.19	0.15	+0.125	16.070	0.233	a, c, f, g, i–r, t, u, x, +
1209	4.5	29 46	2.6	30 14 10.64	0.25	+0.12	15.923	0.236	a, c, f, k, p, r, +
1214	6.2	14 35 14	+2.7	+22 27 36.82	±0.45	-----	—15.627	+0.255	d, q.

* Northern star.

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
1216	3.8	14 35 45	+2.9	+14 12 48.80	±0.15	−0.010	−15.597	+0.268	a, c, g, i–k, m, p, q, t, u, +
1217	5.0	36 6	2.9	8 38 43.90	0.45	−0.02	15.580	0.276	a, c, k.
1218	5.6	36 18	2.9	12 8 51.99	0.4	−0.12	15.568	0.271	a, c, i, n, +
1219	4.9	38 27	2.6	27 0 31.33	0.25	−0.01	15.448	0.252	a, k, m, p, r, +
1223	4.8	39 58	2.8	17 26 35.57	0.3	−0.06	15.364	0.268	a, c, k–m, p, +
1226	6.2	40 47	2.8	15 36 26.87	0.7	+0.03	15.318	0.272	a, c, +
1228	5.8	45 13	2.7	24 22 43.46	0.45	0.00	15,065	0.263	a, d, q.
1231	5.5	46 2	2.4	+37 44 9.45	0.35	+0.07	15.017	0.237	a, e, h, l, m, o, p.
(8115)	6¼ z	47 44	3.6	−32 50 19.51	0.35	0.00	14.919	0.361	p, w, x, z.
(8135)	7 z	50 26	3.6	32 22 34.59	0.4	------	14.759	0.366	a, p, x, z.
(8141)	6.9 z	50 55	+3.5	−24 59 9.85	0.35	−0.04	14.731	+0.351	d, o, p, w, x, z.
1234	2.1	51 3	−0.2	+74 37 1.99	0.1	−0.005	14.723	−0.017	a, c, e, f, i–m, p, q, s–u, +
1235	5.6	51 46	+3.1	0 17 18.77	0.45	−0.01	14.681	+0.310	a, i.
1237	5.4	55 17	2.3	39 42 49.39	0.25	+0.03	14.469	0.238	a, c, e, k, m, r, +
1238	4.8	55 47	0.9	66 22 58.26	0.2	+0.059	14.438	0.102	a, e, k, m, q, u.
1239	4.6	57 11	3.0	+ 2 32 8.24	0.35	+0.01	14.353	0.314	a, c. k, n, o, v.
(8192)	3.2	57 27	3.5	−24 50 13.53	0.25	−0.033	14.336	0.362	c, e, f, i, k, l, p, w, x, z, +
1241	3.6	57 41	2.3	+40 50 12.00	0.1	−0.036	14.321	0.237	a, c, e, f, i–m, p–u, +
1242	5.6	58 36	2.4	35 38 55.10	0.8	------	14.267	0.251	a, c, i.
1244	5.8	14 58 48	1.4	+60 38 55.15	0.3	+0.02	14.253	0.149	a, e, h, o, q, r, +
(8261)	4.9	15 5 47	3.4	−19 21 48.19	0.15	−0.042	13.818	0.365	a, c, e, f, i, k–m, p, q, v–x, z, +
1252	6.4	9 17	2.3	+38 41 17.70	0.35	−0.04	13.594	0.250	e, h, l, p, r.
1257	5.1	13 32	3.1	+ 2 11 35.30	0.3	−0.54	13.318	0.335	a, c, f, i, o, p.
(8367)	6.8z	16 44	3.3	−14 43 48.70	0.2	−0.015	13.108	0.373	a, c, f, g, j, k, m, p, v–x, z.
1262	5.6	16 46	1.8	+52 21 56.34	0.45	−0.01	13.106	0.200	a, b, e, h, r.
1269	5.5	20 33	2.8	15 49 34.01	0.2	+0.005	12.853	0.319	a, c, l, n, p, u.
1275	6.3	22 47	2.6	+25 29 43.52	0.4	−0.02	12.703	0.296	d, g, q, +
(8445)	7½ z	25 35	3.5	−23 29 41.36	0.4	------	12.511	0.407	p, w, x, z.
(8467)	5.3	27 46	3.6	−27 39 56.53	0.35	−0.05	12.362	0.421	d, i, j, p, v–x, z.
1283	5.9	29 21	0.8	64 35 19.90	0.3	+0.08	12.252	0.102	a, c, e, f, m, q, +
1282*	4.4	29 24	2.9	+10 55 2.24	0.35	+0.02	12.250	0.335	a, c, f, g, j, t, +
1284	2.4	29 54	2.5	+27 5 43.68	0.1	−0.094	12.214	0.297	a, e–g, i–n, p–v, x, y, +
(8484)	3.9	30 10	3.6	−27 45 36.61	0.35	−0.015	12.197	0.425	i–l, p, v–x, z.
(8497)	6.3 z	31 24	3.6	27 50 1.74	0.35	−0.03	12.111	0.427	p, w, x, z.
(8516)	5.2	33 36	3.5	−23 27 0.44	0.25	−0.04	11.956	0.419	d, f, i, k, m, p, v–x, z.
1301	6.0	37 21	0.1	+69 38 53.25	0.4	------	11.692	0.021	q, +
1307	3.8	40 58	2.8	15 46 33.91	0.15	−0.041	11.432	0.335	a, c, g, j, l, m, p, q, t, u, +
1308	5.7	42 2	2.8	14 27 49.67	0.45	−0.01	11.356	0.339	a, c, g, n, p, +
1312	4.6	44 51	2.5	26 24 52.78	0.2	−0.08	11.151	0.310	a, c, k–m, p, r, +
1314	3.7	45 11	3.0	4 49 6.30	0.15	+0.059	11.128	0.366	a, c, f, j–n, p, q, t, u, x.
1317	4.8	46 18	2.6	21 19 5.43	0.25	+0.015	11.058	0.259	a, c, k, n, p, r, +
1318	4.7	46 58	2.3	36 0 29.48	0.2	−0.37	10.996	0.280	a, c, f, k, m, p, r, +
1322	4.0	51 14	2.8	16 1 51.62	0.15	−1.286	10.684	0.343	a–c, f, g, j–n, p, q, t, u, x, +
1325	5.4	52 2	2.8	14 44 18.83	0.45	+0.06	10.624	0.347	a, g, n, p, +
1326	4.1	15 52 55	+2.5	+27 12 20.06	±0.15	−0.062	−10.558	+0.313	a, i–n, p–r, t, u, +

* Northern star.

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual preces-sion.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
1330	5.3	15 56 10	+2.7	+18 7 52.21	±0.25	+0.145	−10.316	+0.341	a, c, f, l–n, p, +
1333	5.0	15 57 26	2.6	23 7 7.07	0.25	+0.03	10.221	0.328	a, k, m, +
1337	5.1	16 2 58	2.7	17 20 54.95	0.2	−0.01	9.800	0.348	a, c, f, g, l–n, p, q, +
	6.3	2 59	2.7	17 21 25.48	0.3	−0.01	9.800	0.348	c, f, l, m, p, +
1338	5.2	4 50	2.2	36 46 42.49	0.2	+0.33	9.658	0.285	a, c, f, k–m, p, r, +
1339	4.2	5 12	1.9	45 13 53.54	0.2	+0.043	9.629	0.246	a, c, e–g, k, l, q, r, t, u.
1341	6.1	6 49	2.6	23 47 14.51	0.35	−0.02	9.505	0.331	a, c, i, r, +
1342	5.7	7 40	3.0	+ 5 18 38.18	0.3	−0.005	9.440	0.385	a, n, p.
(8838)	2.8	8 25	3.1	− 3 24 9.50	0.1	−0.137	9.382	0.408	a, c, e, f, i–n, p, q, s–u, x–z, +
1346	{6.36	10 27	2.2	34 8 42.89	0.25	−0.08	9.225	0.297	a, c, f, g, i, m, p, r, +
	{5.86	10 27	2.2	−34 8 41.68	0.35	−0.08	9.225	0.297	f, i, m, p, +
1345	5.9	10 28	2.7	+19 5 37.59	0.3	−0.09	9.223	0.347	a, g, l, n, p, +
1350	5.5	16 3	2.1	39 58 44.63	0.35	−0.025	8.787	0.274	a, e, h, n, p, r.
1352	4.8	16 21	3.0	1 17 42.40	0.35	+0.035	8.764	0.403	a, c, k.
1355	4.5	17 42	2.3	31 9 16.55	0.2	+0.10	8.656	0.312	a, c, k–n, p, r, +
1356	5.1	18 6	2.3	34 3 55.54	0.35	−0.055	8.625	0.301	a, i, k, p, r, +
1357	5.0	18 14	2.3	33 58 0.05	0.35	+0.04	8.615	0.301	a, c, d, i, k, p, r.
1358	5.7	18 40	+2.9	7 12 36.68	0.3	+0.02	8.580	+0.388	a, g, l, n.
1363	5.4	22 4	−0.2	69 22 14.35	0.5	−0.01	8.310	−0.019	a, e, h, m, +
1369	4.7	25 39	+2.6	+20 43 38.40	0.5	-----	8.024	+0.351	a, b, e, f, n–p, +
(8999)	2.9	28 51	3.7	−27 58 50.50	0.25	−0.04	7.767	0.504	c, e, f, i–m, p, q, v–z.
1378	6.1	32 36	2.8	+13 54 59.75	0.45	−0.055	7.464	0.377	c, g, n, +
1387	5.8	37 2	2.4	27 8 6.63	0.4	−0.05	7.102	0.334	c, g, k, p, +
1390	5.8	39 42	2.2	34 14 51.14	0.35	+0.065	6.884	0.306	a, g, p–r, +
1398	5.4	44 50	2.9	7 26 36.78	0.3	+0.005	6.459	0.405	a, c, k, n.
1402	4.4	48 40	2.8	10 21 7.39	0.3	−0.04	6.142	0.396	a, c, i, j, p, q, +
1408	4.0	55 58	2.3	31 5 35.93	0.15	+0.032	5.530	0.324	a, c, e–g, i–n, p–r, t, u, +
1410	6.2	57 18	1.1	56 51 16.49	0.3	+0.02	5.418	0.157	e, f, i, r, +
1417	6.0	16 59 46	2.6	19 45 21.26	0.4	0.00	5.210	0.369	a, q, +
1419	5.8	17 1 31	2.5	+22 14 15.16	0.4	−0.065	5.062	0.361	a, d, g, q, +
(9344)	2.6	3 54	3.4	−15 35 2.45	0.15	+0.097	4.860	0.488	a, c, e, f, i–m, p, q, t–x, z, +
1424	5.1	5 54	1.9	+40 55 8.14	0.4	+0.01	4.691	0.278	a, d, q, +
1427	3.3	8 28	0.2	65 51 13.89	0.15	+0.022	4.472	0.025	a, e–g, i–m, q, t, u, +
1428	3.2+	9 30	2.7	14 31 11.03	0.1	+0.030	4.383	0.391	a, b, e–g, i–n, p, q, s–v, x, y, +
1429	3.3	10 23	2.5	24 58 22.87	0.15	−0.153	4.307	0.353	a, c, f, g, j, m, p, r, u, v, +
1430	5.8	10 48	3.0	1 20 14.23	0.4	-----	4.272	0.435	a, d, q, +
1432	3.4	11 7	2.1	36 56 12.75	0.1	+0.005	4.245	0.300	a, c, j, m, n, p–u, +
1434	5.9	13 4	2.7	17 26 21.68	0.4	-----	4.078	0.382	d, q, +
1435	4.9	13 9	2.2	+33 13 20.00	0.25	−0.01	4.070	0.318	a, j, m, p, r, +
(9445)	6.6 z	14 46	3.7	−24 47 27.09	0.3	−0.04	3.933	0.527	f, k–m, p, w–z.
(9452)	3.4	15 4	3.7	24 53 8.89	0.15	−0.035	3.906	0.528	e, f, i–n, p, q, v–z, +
(9463)	6.8 z	16 13	3.7	−24 59 15.63	0.35	0.00	3.808	0.529	f, p, w, x, z.
(1442)	5.3	16 15	2.5	+24 36 45.13	0.25	0.00	3.805	0.355	a, c, i, l–n, p, r, +
1449	{5.3	19 47	2.1	37 15 4.20	0.3	0.00	3.501	0.298	f, j, m, p.
	{4.5	19 47	2.1	37 15 0.84	0.2	0.00	3.501	0.298	a, f, g, j, m, p, r–t, +
1450	4.4	17 20 54	+3.0	+ 4 14 21.61	±0.2	+0.01	− 3.403	+0.429	a, c, g, i–n, p, x.

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
1452	5.2	17 23 4	+3.1	+ 0 25 21.00	±0.45	−0.03	−3.218	+0.442	a, d, i, n, +
1464	5.9	29 32	1.9	41 19 25.34	0.25	−0.08	2.657	0.277	a, e, h, k–n, r, +
1465	2.2	29 41	2.8	12 38 34.86	0.1	−0.217	2.644	0.402	a, e–g, i–n, p, q, s–v, x, y, +
1471	5.8	32 52	2.5	24 22 40.19	0.3	+0.01	2.369	0.359	a, c, i, n, p, +
1474	6.3	36 5	2.7	15 14 13.31	0.6	−0.06	2.090	0.394	d, p.
1486	5.7	42 9	2.6	17 44 21.00	0.5	−0.045	1.561	0.385	a, q, +
1492	5.4	44 14	2.4	25 39 39.47	0.2	−0.05	1.378	0.354	a, c, f, k, m, p, r, +
1496	6.2	46 52	3.0	1 20 0.15	0.35	------	1.159	0.443	n, q, +
1498	5.3	49 37	2.0	40 1 46.54	0.25	+0.055	0.907	0.285	a, c, e, l, p, r, +
1499	5.8	50 33	3.1	0 41 16.39	0.6	−0.03	0.826	0.446	g, n.
1503	4.0	52 23	2.1	37 15 57.45	0.15	+0.019	0.677	0.300	a, c, d, g, i, j, p–r, t, u.
1507	4.8	54 40	3.0	4 22 35.06	0.45	+0.01	0.466	0.434	a, j, k.
1513	6.1	56 28	2.2	33 13 4.88	0.4	−0.06	0.309	0.320	a, q, +
1517	5.1	17 57 33	2.6	20 50 2.56	0.2	+0.01	−0.214	0.374	a, c, g, k–n, r, +
1522	4.8	18 1 54	2.9	8 43 12.11	0.3	+0.02	+0.166	0.418	a, c, g, l, n.
1525	4.0	3 8	2.3	28 44 50.77	0.15	−0.01	0.274	0.341	a, c, g, i, m, p–r, t, u, +
1527	4.5	3 55	2.6	20 47 49.64	0.3	0.03	0.344	0.374	a, c, g, l, r, +
1531	5.7	5 1	3.0	3 18 10.16	0.4	------	0.439	0.437	d, q, +
1537	5.9	9 19	2.0	38 44 32.34	0.35	0.00	0.815	0.291	d, e, h, m, p, r, +
1543	5.5	14 32	2.5	24 23 58.82	0.25	0.00	1.271	0.359	a, c, i–l, r, +
1549	5.6	16 36	2.3	29 48 19.93	0.25	+0.04	1.452	0.335	a, c, f, l, n, r, +
1551	5.9	17 20	2.8	11 58 28.03	0.4	------	1.515	0.405	q, +
1552	5.5	17 49	2.6	17 46 12.76	0.45	0.00	1.558	0.384	b, c, e, f, h, m, +
1555	5.8	20 13	2.9	7 58 9.73	0.4	------	1.766	0.419	a, d, q, +
1562	5.0	25 39	0.2	+65 29 36.28	0.3	−0.04	2.240	0.022	a, c, e, f, i, m, +
(10107)	5.9	26 59	3.7	−24 6 55.75	0.25	−0.01	2.356	0.530	g, k, l, p, w, x, z.
1571	5.8	31 48	3.1	− 0 24 14.43	0.3	−0.05	2.773	0.444	a, d, q, z, +
1573	0.2	33 7	2.0	+38 40 44.30	0.1	+0.295	2.886	0.289	a, c, e, f, i–n, p–u, x, y, +
(10174)	6.2	34 58	3.7	−23 56 15.61	0.35	−0.03	3.050	0.526	c, i, p, v–x, z.
1575	5.8	35 52	0.2	+65 23 14.20	0.2	+0.027	3.125	0.026	a, e, q, u.
1578	5.1	39 8	3.0	1 56 44.54	0.3	−0.03	3.407	0.434	a, c, g, n, p.
1581*	{ 5.0	40 36	2.0	39 33 8.45	0.15	+0.080	3.532	0.283	a, c, e, f, i, k, m, p–u, +
	{ 6.0	40 36	2.0	39 33 11.54	0.15	+0.080	3.533	0.283	f, i, k, +
1582*	{ 5.3	40 38	2.0	39 29 42.81	0.15	+0.074	3.537	0.284	a, e, f, i, k, p, r, u.
	{ 5.5	40 38	2.0	39 29 40.54	0.15	+0.074	3.537	0.284	a, i, k, p, r, u.
1588	4.5	42 2	2.6	18 3 23.00	0.25	+0.11	3.657	0.379	a, c, k–n, +
1589	5.7	42 36	1.9	41 19 15.77	0.4	+0.02	3.707	0.274	a, d, e, h, r.
	5.3	49 47	2.1	36 49 51.10	0.25	−0.01	4.322	0.296	a, c, g, k, l, q, r.
1602	5.7	49 57	2.9	6 28 28.94	0.25	−0.09	4.336	0.415	a, c, g, l, n, p.
1603	4.6	49 59	2.5	22 30 8.91	0.2	0.00	4.339	0.359	a, c, i, k–n, o, r, +
1608	4.5	50 33	2.1	36 45 19.97	0.3	+0.01	4.387	0.297	a, c, g, k, p, r.
1611	5.7	51 35	3.0	2 23 15.58	0.3	−0.01	4.476	0.428	a, c, i, n.
1615	6.2	53 50	2.6	19 38 28.40	0.4	------	4.667	0.368	d, q, +
1621	5.1	18 55 45	+2.3	+31 59 16.12	±0.25	0.00	+4.831	+0.318	a, c, g, l, n, p, r, +

* Southern star of pair 1581 and mean of pair 1582 usually observed.

Mean places of Hawaiian latitude stars—Continued.

No. C.S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
1630	3.1	19 0 13	+2.8	+13 41 46.18	±0.1	−0.089	+ 5.208	+0.386	a–c, e–g, i–n, p, q, s–u, x, y, +
1633	5.6	1 56	2.5	24 4 33.99	0.4	0.00	5.353	0.349	a–c, f, k, +
1638	5.2	3 16	2.1	35 55 24.54	0.15	+0.009	5.466	0.298	a, c, g, l–n, p–r, u.
1639	5.3	3 28	2.9	5 53 46.56	0.3	−0.07	5.483	0.411	a, i, j, n, p.
1643	5.2	8 1	3.0	2 6 8.83	0.3	+0.01	5.864	0.420	a, c, i, j, n, p.
1646	4.5	9 55	2.0	38 57 6.98	0.25	0.00	6.022	0.282	a, c, e–g, k, m, p, r.
1650	6.2	11 1	2.3	30 19 46.30	0.35	------	6.115	0.321	d, q, +
1654	5.1	12 31	2.8	11 23 32.33	0.15	+0.025	6.239	0.388	a, c, f, g, j–n, p, q, u, x, +
1660	5.4	14 23	2.8	12 9 59.56	0.3	0.00	6.395	0.385	a, c, d, i, m, n, +
1665	5.0	18 13	2.5	26 2 45.38	0.2	−0.025	6.711	0.335	a, c, g, l–n, r, +
1668	5.3	19 35	2.9	11 42 11.48	0.2	+0.63	6.823	0.383	a–c, f, k, m, n, +
1669	4.9	19 40	2.4	29 24 2.84	0.3	+0.01	6.831	0.322	a, c, i, p, r, +
1677	6.2	22 22	2.8	14 3 16.81	0.35	0.00	7.053	0.374	a, d, n, q, +
1680	3.0	26 10	2.4	27 43 21.89	0.1	−0.020	7.363	0.325	a, c, f, g, i, j, l–n, p–u, +
1682	4.8	27 34	2.2	34 12 46.63	0.2	−0.01	7.478	0.300	a, c, g, l–n, p, +
1684	4.7	28 34	2.9	7 8 23.44	0.2	−0.14	7.558	0.391	a, c, f, i–n, p, x.
1692	6.0	31 45	2.2	36 41 39.30	0.2	0.00	7.814	0.286	a, c, g, l–n, r.
1697	5.0	33 37	3.0	5 8 27.54	0.3	0.00	7.966	0.393	a–c, i, j, n, p, x.
1699	4.9	34 55	2.4	29 53 35.77	0.25	+0.04	8.069	0.313	a, c, j, m, p, r, +
1705	5.4	37 15	2.8	11 33 41.46	0.35	+0.02	8.256	0.372	a, c, i, j, n, p, +
1711	5.8	40 10	2.9	7 20 22.94	0.25	−0.015	8.488	0.383	a, c, g, l, n.
1712	5.0	40 12	2.2	37 4 54.35	0.15	+0.042	8.490	0.282	a. c, f, k, p–r, u, +
1715	5.0	42 8	2.3	33 27 54.19	0.2	−0.45	8.643	0.296	a, c, d, f, g, k–m, r, +
1720	1.0	45 16	2.9	8 34 13.93	0.1	+0.384	8.890	0.375	a, e–g, i–n, p, q, s–v, x, y, +
1724	5.5	46 34	2.1	38 25 55.25	0.25	+0.105	8.993	0.274	a, c, e, f, h, l, p, r.
1725	3.9+	46 43	3.1	0 42 58.61	0.15	−0.003	9.003	0.395	a, c, f, j–l, n, q, t, u, x.
1737	5.7	50 41	2.2	36 41 52.43	0.35	−0.05	9.313	0.279	d, p, q, +
1742	4.7	51 49	2.1	38 11 11.68	0.25	−0.02	9.401	0.273	a, c, e, l–n, p, r, +
1744	5.3	52 38	2.7	16 29 7.56	0.3	+0.03	9.462	0.347	a, c, f, l, n.
1750	5.7	54 20	2.6	22 47 39.51	0.2	+0.02	9.594	0.327	a, k, m, n, r, +
1758	5.6	19 58 37	2.9	6 57 34.66	0.25	+0.01	9.922	0.368	a, c, i, l, n, p, q.
1761	5.4	20 0 9	2.7	19 40 4.10	0.3	+0.085	10.038	0.332	a, c, f, l, n, p, +
1765	5.3	2 2	2.6	23 17 20.72	0.2	−0.01	10.182	0.320	a, c, i, l–n, p, r.
1771	6.2	3 22	2.3	34 5 42.89	0.35	0.00	10.280	0.283	d, p, q, +
1775	5.5	5 51	2.5	26 34 10.70	0.25	0.00	10.467	0.308	a, c, i, k, l, p, r, +
1778	5.1	9 3	2.8	14 51 14.56	0.2	+0.07	10.704	0.338	a, c, j, k, m, n, p, q, +
1783	5.0	10 18	2.2	36 27 38.40	0.25	+0.09	10.797	0.271	a, c, f, g, l, n, p, r, +
1784	4.8	10 28	2.5	25 14 49.17	0.35	−0.045	10.810	0.308	a, b, d, h, k, n, o, r, +
1795	6.5	14 11	2.8	12 51 47.64	0.45	−0.06	11.082	0.338	a, n, q.
1796	5.2	14 19	2.3	34 37 48.14	0.25	+0.01	11.090	0.276	a, c, g, l, m, r.
1798	5.4	17 35	3.0	4 58 55.61	0.5	−0.07	11.327	0.354	a–d, g, h, n, p.
1815	6.3	27 8	2.6	25 25 24.47	0.35	------	12.007	0.295	d, q, +
1820	5.2	28 36	2.8	12 38 26.88	0.25	+0.04	12.111	0.325	a, c, g, l–n, p, +
1822	4.7	30 1	2.8	14 17 5.63	0.25	0.00	12.209	0.320	a, c, f, i, k, n, p, q, +
1825	5.6	20 32 15	+2.6	+26 4 8.68	±0.25	−0.015	+12.363	+0.289	a, c, i, m, p, r.

Mean places of Hawaiian latitude stars—Continued.

No. C. S. (Stone).	Mag.	Right ascension, 1887.	Ann. var.	Declination, 1887.0.	Pr. error, 1887.	Proper motion.	Annual precession.	Change, 100 y.	Authorities.
		h. m. s.	s.	° ′ ″	″	″	″	″	
1829	6.1	20 33 24	+2.8	+12 55 7.93	±0.25	−0.01	+12.442	+0.319	a, d, k, l, n, +
1837	4.0	34 23	2.8	15 30 50.04	0.15	−0.002	12.510	0.312	a, f, g, i–n, p, q, t, u, x, +
1851	2.7	41 38	2.4	33 32 50.45	0.1	+0.335	12.999	0.261	a, f, g, j–l, p–u, +
1855	5.2+	42 40	2.4	33 57 33.66	0.5	------	13.068	0.259	o, p, +
1860	6.1	44 16	2.9	7 56 40.21	0.3	+0.01	13.174	0.319	a, c, g, m, n, p.
1870	5.9	20 50 1	3.0	+ 4 6 5.30	0.4	0.00	13.549	0.318	a, c, g, n, p.
(11238)	4.6	21 3 26	3.3	−11 49 43.09	0.2	−0.007	14.391	0.327	a, c, e, i–m, p, w, x, z, +
1898	4.8	4 51	2.9	+ 9 40 36.44	0.2	−0.175	14.476	0.288	a, c, f, k, l, n, p, q, x.
	5.9	5 2	2.9	9 35 18.60	0.3	+0.01	14.487	0.288	c, f, m, n, p.
1900	5.7	6 46	1.9	53 6 6.73	0.2	−0.015	14.592	0.179	a, c, e, m, n, r, s, t.
1901	3.5	8 8	2.5	29 45 49.36	0.1	−0.066	14.674	0.248	a, c, e–g, i–n, p–r, t, u, x, y, +
1902	4.6	8 59	2.9	+ 9 32 58.29	0.2	−0.295	14.724	0.283	a, c, f, k, n, x.
(11276)	5.5	6 29	3.3	−15 38 25.43	0.2	0.00	14.755	0.323	a, c, e, i–m, p, x, z.
1904	4.1	10 10	3.0	+ 4 46 52.15	0.15	−0.078	14.794	0.290	a, c, i–n, p, t, u, x.
1907	4.4	13 16	2.5	34 25 21.46	0.25	−0.02	14.977	0.233	a, c, e, f, j, p, r, +
1912	6.0	15 29	3.0	6 52 32.95	0.3	−0.025	15.105	0.279	a, c, n, p.
1928	5.4	22 41	2.6	27 7 0.80	0.25	+0.02	15.512	0.238	a, c, d, f, l, m, r, +
1936	5.9	25 42	2.9	11 38 29.49	0.35	0.00	15.677	0.258	a, d, o, q, +
1044	5.1	32 25	2.4	39 54 22.00	0.15	+0.009	16.037	0.204	a, c, e, l, p–r, u, +
1947	5.4	33 49	3.0	1 44 9.47	0.3	−0.08	16.110	0.259	a, c, l, n, p.
1950	5.8	36 24	3.1	0 46 15.17	0.3	−0.025	16.244	0.256	a, c, g, l, n.
1953	5.3	21 37 50	2.4	40 33 41.48	0.3	+0.01	16.318	0.198	c, e, l, p, r, +
2017	5.1	22 15 57	3.0	11 38 9.85	0.15	+0.010	18.022	0.182	a, c, k, m, n, p, q, +
2018	4.9	16 6	2.8	27 45 41.56	0.2	0.00	18.027	0.170	a, c, i, l–n, p, r, +
2022	4.6	19 30	3.1	0 48 14.99	0.2	−0.01	18.156	0.183	a, c, f, i, k, l, n, p, q, x.
2043	6.3 e	30 50	2.7	39 2 36.23	0.35	−0.02	18.555	0.141	c, e, f, l, p, +
	5.8 e	30 51	2.7	39 2 58.59	0.3	−0.02	18.556	0.141	a, c, e–g, l, p, r, +
2054	3.6	35 50	3.0	10 14 29.89	0.1	−0.018	18.716	0.149	a–c, e–g, i–q, s–v, x, y, +
2057	3.1	37 42	2.8	29 37 49.42	0.15	−0.033	18.774	0.137	a, c, f, g, i, j, m, p–r, t, u, +
2077	6.0	49 47	2.8	36 28 28.16	0.35	------	19.120	0.115	d, q, +
2082	5.6	53 40	3.1	0 21 34.45	0.3	−0.08	19.219	0.121	a, d, f, l, n, p.
2087	3.8	56 43	2.7	41 43 7.80	0.15	0.00	19.294	0.102	a, c, e, i–k, m, p–u, +
2089	4.6	58 8	3.1	3 12 42.33	0.25	−0.015	19.327	0.111	a, c, e, f, i, k, l, p, x.
2090	2.6+	58 18	2.9	27 28 11.70	0.15	+0.133	19.330	0.105	a, c, f, i–m, p, r, t, u, +
2091	2.6	22 59 8	3.0	14 35 50.94	0.1	−0.030	19.349	0.107	a, b, f, g, i–n, p, q, s–u, x, y, +
2095	4.9	23 1 37	2.9	24 51 30.99	0.2	−0.02	19.406	0.100	a, c, k–m, p, r.
2104	6.1	5 5	3.0	16 58 58.32	0.6	+0.02	19.481	0.098	c, n, +
2179	5.8	23 59 54	+3.1	+12 46 2.07	±0.25	0.00	+20.053	+0.007	a, c, g, l–n, p, +

GRAVITY.

Descriptions of stations.

Pakaoao.—This station is situated on the edge of the crater of Haleakala, near the southwestern corner (see illustrations Nos. 39 and 42). It was connected trigonometrically with Haleakala △ point by Mr. F. S. Dodge. The distance from the △ station to the latitude pier is 71.8 feet and the azimuth 145° 12′. The pendulum-house was about 12 feet south of the latitude pier (see illustration No. 42).

The lower end of the pendulum was 24 feet below the △ point, the height of which is given by the Government Survey as 9,870 feet above mean tide. This point has since received the name of Pendulum Peak. (Am. Journal of Science, February, 1889.)

Haiku.—The pendulums were swung in the basement of the old sugar-mill on the plantation of Mr. Henry Baldwin. It is situated about 4 miles east of Paia. Around the pendulum support was built a tight wooden compartment 5 feet square and 10 feet high to prevent disturbance by currents of air. The latitude pier was situated a few feet north of the building. The connection of the latitude pier with the triangulation station at Puu o Umi was also made by Mr. Dodge, who gives the height of the bottom of the pendulum above mean tide as 385 feet.

Honolulu.—The northeast corner room of the Government building (Kapuaiwa) was chosen for the observations at this station, the pendulums being hung against the east wall from two heavy iron brackets. A weight somewhat heavier than the heaviest pendulum was placed at the extremity of the arms and no flexure which could affect the result of the observations was detected. Time was determined at the new observatory about 50 feet eastward of the building, and the signals were transmitted electrically to the chronograph, which was in the pendulum-room. Around the pendulums were placed screens to prevent rapid changes of temperature and currents of air. The bottom of the pendulum was 10 feet above mean tide.

San Francisco.—Davidson Observatory in Lafayette Park, at the corner of Clay and Octavia streets, was occupied. The pendulums were swung from a stand (see illustration No. 49) and were observed from an adjoining room. The station is 378 feet above mean tide.

Lick Observatory.—Observations were made in the cellar of the transit house. The top plank of the stand used in San Francisco was supported at one end by the east collimator pier, and at the other by a brick wall. The pendulums were 4,205 feet above mean tide.

Washington.—The pendulum-room at the Smithsonian Institution, the northeast corner of the basement, was occupied. The pendulums were swung from a stand (see illustration No. 49) similar to the one used in San Francisco. The height of the station above mean tide is 34 feet.

Methods of observation.

The plan generally followed was to swing the pendulums at each station on the same support and to continue the observations through the entire twenty-four hours. This method was adhered to as far as local circumstances would permit. A wooden stand (illustration No. 49) was used at San Francisco and Washington. A heavy plank imbedded in masonry was used at Pakaoao and the Lick Observatory, and this same plank was used at Honolulu and Haiku firmly supported on massive iron brackets which were imbedded in a stone wall. Head No. 0 was used at all the stations. At the Lick Observatory only day observations were made. The iron brackets were tested for vertical flexure. No appreciable amount was discovered. The horizontal flexure of the head is supposed to have been the same at each station. The knife-edge plane was tested for horizontality before beginning each position and also after its conclusion. Three thermometers were used, suspended near the top, middle, and bottom of the pendulum, the bottom one being attached to a rod of the same metal as the pendulum and read continuously during the swing by means of the telescope used in taking the transits. The others were read at the beginning and end of swings. The thermometers were compared immediately after the observations at each station and had their zero points determined at Honolulu, San Francisco, and Washington. The pendulums were allowed to swing for 15,000 oscillations with the heavy end down and for 5,000 in the inverted position.

Time was determined at 8 p. m. and the pendulums were started at the mean epoch of the star observations. The half amplitude of oscillation was about 50′ at the beginning and 5′ at the end.

Two barometers, mercurial and aneroid, were read as well as the wet and dry bulb thermometers. The pendulum observations were registered electrically on a Fauth chronograph (illustration No. 50). Forty transits were taken at the beginning and end of swings, with one or two intermediate ones at intervals of an hour in order to count the whole number of oscillations. The probable error of the mean of forty transits is about $0^s.003$.

The approximate value of an oscillation may be obtained at a new station by applying a correction of one one-hundred-thousandth of a second for a change of one second in the rate of the clock, 1 degree in the temperature, 1 inch in the pressure, one-hundredth of the radius in the amplitude, 100 metres in the elevation or ten minutes in the latitude (20°). But this method was checked at each station from transits near the end of a swing. The rule adopted was to take sixty transits, allow ten minutes to elapse, and take forty more. Allow thirty minutes to pass and take forty additional transits. This with the regular observations gives sufficient data for the determination of the period to the nearest ten-thousandth of a second, which is sufficiently accurate to make the count during an interval of two hours.

The chronometer correction was determined by observing ten stars each evening. Four time stars and one circumpolar were taken in each position of the instrument and transits were observed across the five middle threads of the diaphragm. Readings of the level were made before and after each set and during the observations if time served. The transits were registered electrically on the Fauth chronograph.

The observations on the pendulum and the thermometer below were made by means of a reading telescope at a distance of about 15 feet. A window of plate-glass was built in the front wall of the pendulum-house at Pakaoao, and a theodolite standing in the transit tent was used in observing.

Methods of reduction.

The corrections to the time of oscillation on account of the amplitude were calculated by Borda's formula

$$\frac{Mn}{32}\,\frac{\sin(\varphi+\varphi')\sin(\varphi-\varphi')}{\log\sin\varphi-\log\sin\varphi'}$$

φ and φ' being the initial and final arcs, n the number of oscillations, and M the modulus of the common system of logarithms.

In finding the periods, the use of eight-place logarithms was avoided by using the formula

$$\frac{B}{A\pm i}=\frac{B}{A}\left(1\mp\frac{i}{A}\pm\frac{i^2}{A^2}\mp\text{etc.}\right)$$

As the entire interval was only increased by about its $\frac{1}{300000}$ part on account of the amplitude, all terms involving higher powers than the first are inappreciable in the seventh place, and $\frac{i}{A}$ can be disposed of mentally, only requiring one or two places.

The corrections for pressure and temperature depend on Peirce's co-efficients. The atmospheric effect is considered in two parts, the first varying directly as the pressure and inversely as the temperature, and the second directly as the square root of the pressure and inversely as the eighth root of the temperature. As communicated by Professor Peirce, the co-efficients for Washington in sidereal time at one absolute atmosphere (1,000,000 C. G. S. units of pressure) and 15° Centigrade are:

Pendulum.	Heavy end down.		Heavy end up.	
	First part.	Second part.	First part.	Second part.
	Seconds.	*Seconds.*	*Seconds.*	*Seconds.*
No. 3.	0.0003107	0.0000349	0.0008821	0.0001047
No. 4.	0.0003315	0.0000428	0.0009905	0.0001274

For any other station the correction is

$$\left(\sqrt{\frac{g_w}{g}}-\frac{288.1}{t+273.1}\quad\frac{\mathrm{P}}{29.554}\sqrt{\frac{g}{g_w}}\right)\mathrm{K}$$

K being the co-efficient for Washington, g_w gravity at Washington, g gravity at any other station, t the temperature Centigrade, and P the pressure in inches.

The temperature corrections used for one oscillation per degree Centigrade are:

Pendulum.	Heavy end down.	Heavy end up.
	Seconds.	*Seconds.*
No. 3.	0.00000877	0.00000878
No. 4.	0.00000921	0.00000920

Differential corrections were first applied to reduce to the mean temperature and pressure of the station. The mean period is then brought to 15° temperature and to one absolute atmosphere.

The attraction of Haleakala on the plumb-line at Kaupo (Ka Lae o Ka Ilio) was calculated by Hutton's formula

$$\mathrm{A}=\rho\int_{a_1}^{a_2}\int_{r_1}^{r_2}\int_{o}^{h}\frac{r^2\cos a da, dr, dz}{(r^2+z^2)^{\frac{3}{2}}}$$

(Clarke's Geodesy, page 295) using a value for ρ derived from a comparison of the pendulum observations at the summit and at the sea.

The island of Maui is divided into compartments by radial lines and concentric circles following the usual method. In the present case the first series of circles extends to the summit. They have a common difference in the radii of 1 mile. The second series extends to the valley beyond, with radii having a ratio of $\frac{11}{10}$. The third series includes all remaining matter above the sea-level (see illustration No. 51). The sines of the angles between the radii and the meridian of Ka Lae o Ka Ilio have a common difference of one-tenth. This arrangement facilitates the computation by making the attractions vary as the heights for the compartments in any given ring. The unit of height is taken as 100 feet, and we have the following heights for East Maui:

Compartment heights.

Circle.	Sector.										Sums.
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	
1– 2	1.0	4.0	4.5	7.5	9.0	9.0	9.5	10.0	10.0	10.0	74.5
2– 3	4.5	8.0	12.0	14.0	15.0	16.5	17.5	18.0	19.5	20.0	145.0
3– 4	4.5	12.5	14.5	20.0	23.0	25.0	27.5	30.0	31.5	31.0	219.5
4– 5	8.5	20.5	26.0	31.5	40.0	43.0	46.0	46.0	44.0	42.0	347.5
5– 6	13.0	30.0	38.0	48.0	57.5	65.0	68.0	61.0	54.0	53.5	488.0
6– 7	20.0	40.0	52.0	66.0	73.0	75.0	75.0	69.0	63.5	65.0	598.5
7– 8	26.5	52.0	68.0	76.5	76.0	73.5	72.5	73.0	73.0	77.5	668.5
8– 9	32.5	63.5	79.0	78.5	73.0	73.0	74.5	76.5	74.5	72.0	697.0
9–10	38.0	75.0	95.0	84.5	75.5	71.0	72.5	71.5	66.5	62.0	711.5
10–11	44.5	79.5	83.5	87.5	80.5	71.5	64.0	62.0	60.0	54.0	687.0
11–12	56.0	73.0	77.5	77.5	76.5	69.5	58.5	54.5	52.5	45.5	641.0
12–13	42.5	64.0	65.0	65.5	63.0	59.5	54.5	46.0	41.0	36.0	537.0
13–14	43.0	49.0	49.0	51.5	51.0	50.0	47.0	39.0	29.0	22.5	431.0

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

Please Note:

This project currently includes the imaging of the full text of each volume up to the "List of Sketches" (maps) at the end. Future online links, by the National Ocean Service, located on the Historical Map and Chart Project webpage (http://historicals.ncd.noaa.gov/historicals/histmap.asp) will includes these images.