# 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, 1885.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1886.

# National Oceanic and Atmospheric Administration

## Annual Report of the Superintendent of the Coast Survey

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FEBRUARY 18, 1886.

*Resolved by the Senate (the House of Representatives concurring)*, That there be printed 3,000 extra copies of the report of the Superintendent of the Coast and Geodetic Survey, showing the progress made in said Survey during the year ending June 30, 1885, for distribution by said Superintendent.

Adopted in House July 17, 1886.

LETTER

FROM

# THE SECRETARY OF THE TREASURY,

TRANSMITTING

*The report of the Superintendent of the Coast and Geodetic Survey showing the progress made in that work during the last fiscal year.*

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DECEMBER 17, 1885.—Laid on the table and ordered to be printed.

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TREASURY DEPARTMENT,
*December* 12, 1885.

SIR: In compliance with section 4690, Revised Statutes of the United States, 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 ending June 30, 1885, and accompanied by a map illustrating the general advance in the operations of the Survey.

Respectfully yours,

D. MANNING,
*Secretary.*

To the SPEAKER OF THE HOUSE OF REPRESENTATIVES.

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# ABSTRACT OF CONTENTS OF REPORT.

# TITLES OF APPENDICES.

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## ERRATA.

*In Coast and Geodetic Survey Report for* 1885.

Page 14, fifth line from bottom, insert missing letters in ***including.***
Page 24, ninth line from top, for *Oan Orden* read *Van Orden.*
Page 27, sixth line from bottom, for *resurveg* read *resurvey.*
Page 96, twenty-second line from top, for *of* read *at.*
Page 472, seventeenth line from top, for *record of* read *record* **at.**
Page 475, twenty-first line from top, for *from* read *for.*
Page 476, ninth line from top, *dele* $\triangle$.
Page 476, nineteenth line from top, for cBP put CBP.
Page 476, twentieth line from top, for cAP′ put CAP′.
Page 476, twenty-first line from top, for PcB put PCB.
Page 485, fourth line from top, for *Dart* put *Dash.*

# REPORT.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
*Washington, December* 9, 1885.

SIR: The report of progress made in the work of the Coast and Geodetic Survey during the fiscal year ending June 30, 1885, which I have the honor to submit herewith, as required by law, and by the regulations of the Treasury Department, is accompanied by maps showing the general advance of the survey on the Atlantic, Gulf of Mexico, and Pacific coasts and in the interior of the United States, and by an appendix exhibiting in tabular form the distribution of the several parties, the nature of their work, and the localities of their operations.

In its arrangement, this report conforms to that adopted in the recent reports of the Superintendent of this Bureau.

Part I presents general statements of progress under the several heads of field-work, office-work, discoveries, and developments, and special scientific work; it gives also an explanation of estimates and estimates in detail for the fiscal year 1886–1887.

Part II is occupied with summaries of work afloat and ashore as derived from the reports of chiefs of parties during the past fiscal year. It closes with references to the office work.

In Part III are comprised the several appendices which relate to field, office, and hydrographic details, and also those appendices which present the methods, discussions, and results of the survey in forms deemed worthy of publication.

The important step taken by the last Congress in appointing a Joint Commission of three Senators and three Representatives to "consider the present organizations of the Signal Service, Geological Survey, Coast and Geodetic Survey, and the Hydrographic Office of the Navy Department, with the view to secure greater efficiency and economy of administration of the public service in said Bureaus," led, as is well known, to a request from that Commission that the National Academy of Sciences would appoint a committee of its members to examine the subject, and give the Joint Commission the benefit of their special knowledge of the questions involved.

In pursuing their inquiries, the committee of the Academy requested from the Superintendent through the Secretary of the Treasury a statement of the organization and present condition of the Coast and Geodetic Survey. This statement accompanied the report of the Academy to the Commission. It embodies views deemed worthy of consideration respecting the relations of the Coast and Geodetic Survey to other Government surveys, and the methods by which the functions of these several surveys may be clearly defined, and their co-ordination well established. It has been published by the Academy in their annual report, and appears also in the Testimony before the Joint Commission (Senate Mis. Doc. No. 82, Forty-ninth Congress, first session).

The reasons urged in the last annual report for an increase in the amount appropriated for party expenses, or the cost of field work, afloat and ashore, it is gratifying to record, met with cordial support from the Department, and were recognized, though not to the full extent desired, by Congress. These reasons have lost none of their force, and I would again urge an increase in the sum available for party expenses to the amount asked for in the estimates.

# PART I.

It is believed that during the past fiscal year the progress of the Survey in all of its branches has been commensurate with the means afforded by Congress. And although in certain sections, operations have been necessarily restricted, or temporarily suspended for want of funds, yet every effort has been made, consistently with the terms of the appropriation, to push work in important localities, as is shown in the advance towards completion of the resurveys of Long Island Sound and Delaware Bay, the beginning of the resurvey of New York Bay and Harbor, the investigation of the currents in the Gulf Stream, and of the changes in the bar at San Francisco Entrance.

The distribution of the land and water parties on the Atlantic, Gulf, and Pacific coasts and in the interior of the United States is shown in Appendix No. 1, in the geographical order heretofore observed.

In the course of the hydrographic operations, some important developments were made to which the attention of persons interested in commerce and navigation was promptly called. Statements in detail of these discoveries and developments are given in Part II; they are referred to also under a special heading in this part of the report.

Among them may be mentioned the location of rocks and rocky ledges off the coasts of Maine and Massachusetts; the location of shoals hitherto uncharted in Vineyard Sound, and the development of changes in the main ship-channel in that sound; the discovery of dangerous ledges in the course of the resurvey of Long Island Sound; the location of a dangerous rock in East River, New York, near Diamond Reef, and the development of Sabine Bank, off Sabine Pass, Gulf of Mexico.

Operations afield and afloat have been carried on within the limits or off the coasts of thirty-two States, two Territories, and in the District of Columbia. The transcontinental geodetic work intended to unite the survey of the Atlantic with that of the Pacific coast is making progress simultaneously from the Atlantic coast westward and the Pacific coast eastward, and is advancing toward a junction. Trigonometrical surveys were continued in nine States, which have made requisite provision for their own topographical and geological surveys. This work in the interior, carried on by authority of the act approved March 3, 1871, is gradually establishing an exact skeleton or framework, by means of which accurate base-lines are afforded for State surveys, by which the lines of the public land surveys can be checked in position and direction, and by which the preparation of accurate State maps is rendered possible. The practical advantages and scientific aims of such a general framework, which must of necessity be under national control, are concisely set forth in the report of Superintendent J. E. Hilgard to the National Academy of Sciences, bearing date of September 19, 1884.

## GENERAL STATEMENT OF PROGRESS.

### I.—FIELD-WORK.

ATLANTIC COAST.—During the year ending June 30, 1885, the work of the Survey has included the following operations upon the coasts and within the borders of the New England States: Topography of Machias Bay entrance, Machiasport, and of the coast to the eastward continued; topographic surveys of Chandler's Bay and Englishman's Bay, and hydrographic surveys of Narraguagus River from Millbridge to Cherryfield, of Harrington River, including Flat and Back Bays, and of Pleasant River to Addison, coast of Maine; topographical survey in the vicinity of Prospect Harbor, Gouldsborough, and resurvey of Bar Harbor, Mount Desert Island, Maine; record of observations with self-registering tide-gauge continued, and meteorological observations recorded at Pulpit Cove, North Haven Island, Penobscot Bay; hydrographic examinations of York Harbor, Maine, between Marblehead Rock and Marblehead Neck, Massachusetts, and off Bass Point, Nahant, Mass.; geodetic operations continued in the States of New Hampshire and Vermont; trigonometrical operations begun in aid of a topographical survey of the State of Massachusetts; hydrographic examinations in Vineyard Sound, Narragansett Bay, and Block Island Sound; magnetic observations at Providence, R. I., and on Coaster's Harbor Island, Narragansett Bay; tidal observations with a self-registering gauge continued at Providence, R. I.; topographical resurveys at the mouth of the Connecticut River, and near Milford and Stratford, Conn. on the north shore of Long Island Sound; also, in the vicinity of Madison, Guilford, and Branford, Conn.; inshore hydrographic resurvey of the northern coast of Long Island Sound from Hammonassett Point to Welch's Point, Connecticut; tidal observations with an automatic tide-gauge at the New Haven Breakwater; continuation of the topographic resurvey of the north shore of Long Island Sound from Farms (or Frost) Point westward; triangulation extended in the western part of Long Island Sound from Stamford Harbor Light and Lloyd's Neck towards New Rochelle; and topographical resurvey of the north shore of Long Island Sound continued from Darien, Conn., towards New Rochelle, N. Y.

Upon the coasts and within the limits of the States of New York, New Jersey, Pennsylvania, and Delaware, field operations have included topographical resurveys of the northeastern coast of Long Island in the vicinity of Gardiner's Bay, Shelter Island, and Greenpoint; hydrographic work off Terry Point and Rocky and Horton's Points, Long Island; triangulation in the western part of Long Island Sound extended from Lloyd's Neck westward towards New Rochelle; topographical resurvey of the north shore of Long Island carried eastward from Lloyd's Neck; topographical resurvey of the shores of the East River, New York, and hydrographic resurvey of that river; determination of points for the resurvey of New York lower Bay; topographic resurvey of the shore lines of Coney Island and Rockaway Beach; hydrographic resurvey of New York Bay Entrance; topographic resurvey of the shores of the North River, New York; development of plans for the study of the physical hydrography of New York Bay and Harbor; tidal observations with self registeringtide-gauges at Governor's Island and at Sandy Hook; topographical resurvey of Sandy Hook; extension of reconnaissance and triangulation in the southern part of the State of New Jersey and in the eastern portion of the State of Pennsylvania; reconnaissance for triangulation in the western half of the same State; special triangulation for the city of Philadelphia; and of the Delaware River from Petty's Island to Poquessink Creek; comparison of recent with former surveys of the Delaware River and location of port-warden lines for the harbor of Philadelphia; magnetic observations at Philadelphia; determination of the position of a wreck off Barnegat; continuation of triangulation and reconnaissance on the New Jersey coast, magnetic station occupied on that coast, and topographic survey continued; continuation of the topographical resurvey of the New Jersey shore of Delaware Bay, and completion of the topographical resurvey of the opposite shore of that bay; advance towards completion of the hydrographic resurvey of lower Delaware Bay and the Entrance.

The operations of the Survey 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, and South Carolina, have included gravity determinations and experimental researches at Washington, D. C., and in Virginia; annual determination of the magnetic declination, dip, and intensity at a station on Capitol Hill, Washington; continuation of the detailed topographical survey of the District of Columbia; lines of leveling of precision carried from Ashland, Va., to Fortress Monroe; also a line to connect the bench-mark near the Washington Aqueduct Bridge with the Capitol bench-mark; determination of points on the boundary line between Maryland and Virginia; hydrographic examinations off Cape Henry, Va.; supplementary topographical survey between Norfolk and the ocean shore; extension of the primary triangulation near the thirty-ninth parallel from West Virginia into Kentucky and Ohio, and hydrographic survey in Stono and Wadmelaw Rivers, South Carolina.

Upon the east and west coasts of Florida; in the approaches to this coast, and upon the coasts and within the limits of the Gulf States, field operations included the triangulation, shore-line topography, and hydrography of Saint John's River between Racy Point and Palatka; deep-sea soundings in Northwest Providence Channel and soundings and current observations in the Gulf Stream between Fowey Rocks and Gun Cay, Bahamas; determination of gravity at Key West; beach measure and topographical survey on the west coast of Florida from Bowditch Point to Cape Romano, and hydrography of that coast from the vicinity of Gordon's Pass to Cape Romano; continuation of reconnaissance for the connection of the triangulation of the Gulf coast with that along the Blue Ridge; hydrographic work in Mobile Bay and around the Chandeleur Islands; determination of the longitudes of Little Rock, Texarkana, and Fort Smith, Ark.; triangulation and topography of the coast of Louisiana from Coté Blanche Bay to the westward; hydrographic survey off the coast of Louisiana from Sabine Pass eastward; determination of the longitude of Brownsville, Tex., and triangulation and wire measurement between Point Isabel and Brownsville.

PACIFIC COAST.—Field operations upon the coasts and within the boundaries of the States of California and Oregon, of Washington Territory, and of Alaska, have included the survey of the coast line connecting the work at San Juan Capistrano with that at Newport Bay; continuation of the series of observations with magnetic self-registering instruments at Los Angeles, Cal.; continuation of the primary triangulation of the California coast north of Point Concepcion; survey of the coast westward from Moro Bay continued; hydrographic survey of the coast in the vicinity of San Simeon, Cal.; occupation of stations in continuation of the primary triangulation of the coast of California; self-registering tide-gauge record kept up at Saucelito, San Francisco Bay; hydrographic surveys on the California coast in Humboldt Bay and between Brushy Point and White Rock; continuation of the survey of the Umpquah River, Oregon, and of the topographical and hydrographical survey of the Columbia and Willamette Rivers; completion of the topography of Hood's Canal, Washington Territory, and reconnaissance of the Olympic Mountains; hydrographic surveys in Hood's Canal, and triangulation and topography of Possession Strait and Sound, Washington Territory; reconnaissance for the triangulation of the Strait of Fuca, and hydrographic survey in that strait; hydrographic surveys in Southeastern Alaska, and tidal observations continued with self-registering tide-gauge at Saint Paul, Kadiak Island, Alaska.

INTERIOR STATES.—In the States between the Atlantic and the Pacific coasts, field-work has included a reconnaisance for extending the primary triangulation near the thirty-ninth parallel from West Virginia into Kentucky and Ohio; occupation of stations in continuation of the triangulation of the State of Tennessee; continuation of geodetic operations in the States of Ohio, Indiana, and Wisconsin; extension of the primary triangulation near the thirty-ninth parallel eastward across the State of Illinois; progress made in connecting the line of transcontinental leveling with a point on the Gulf coast; occupation of stations for continuing to the westward the primary triangulation near the thirty-ninth parallel in Missouri and Kansas; determination of the longitude of Kansas City, Mo., and continuation of the reconnaissance and transcontinental triangulation to the eastward in Utah.

SPECIAL OPERATIONS during the fiscal year included an examination of methods of observation and photographic processes employed at the Magnetic Observatory, Toronto, Canada; the direction of the suboffices at Boston, New York, Philadelphia, and San Francisco; the charge of the exhibit of the Coast and Geodetic Survey at the New Orleans Exposition; the transfer of the new steamer Patterson from the Atlantic to the Pacific coast, and the continuation of the automatic tide-record at a station in the Sandwich Islands.

## II.—OFFICE WORK.

In the course of office operations during the past fiscal year, the calls for information from the several Departments of the Government and requests from individuals were promptly met; special attention was given to a discussion of the secular variation and geographical distribution of the magnetic dip and intensity throughout the United States; the changes required upon the charts by the results of resurveys in important localities were deemed matters of pressing necessity and were incorporated in the published editions without delay; improvements were made in the batteries used for electrotyping; an addition was built to the plate-printing room, and a new copper-plate press of large size added; the prediction tide-tables for the year 1886 were prepared for publication; fac simile copies of topographic sheets were published by photo-lithography, and improvements were begun in the instrument-room which promise increased facilities of construction and repair.

Twenty seven new charts were published, of which 16 were photo-lithographs. For the use of the topographical and hydrographical parties, ninety-nine projections on various scales were prepared. Corrections and additions were made upon four hundred and twenty-one plates of charts, and fourteen plates of sketches. The engravings of eleven plates of charts were completed; also the engraved plates of nine new editions of charts. Forty-six basso and sixty-one alto electrotype plates were made; of these numbers, thirteen bassos and fourteen altos were for the Engineer Corps, United States Army, and seven bassos and seven altos for the Hydrographic Office, Navy Department.

Distribution was made during the year of twenty-eight thousand nine hundred and five copies of charts. Of this number ten thousand seven hundred and forty were issued to meet demands from the several Executive Departments and one thousand four hundred and twenty-three to Senators and Representatives in Congress.

## III.—DISCOVERIES AND DEVELOPMENTS.

The following is a summary of dangers to navigation discovered in the course of hydrographic operations during the fiscal year. These dangers were developed by officers of the navy on Coast Survey duty, and were promptly reported to the Office. "Notices to Mariners" were then issued giving full descriptions of the several localities, with distances and bearings of the rocks or shoals as referred to prominent objects. Statements in detail in regard to these dangers will be found in Part II with the names of the officers by whom they were reported:

No. 52 (August 11, 1884) gave information of a dangerous rock in East River, New York, near Dimond Reef.

No. 54 (October 7, 1884) described a rock off York Harbor, Maine; a rock between Marblehead Rock and Marblehead Neck, Massachusetts, and gave directions for avoiding Flip Rock, off Bass Point, Nahant.

No. 55 (November 1, 1884) warned navigators of a sunken ledge near Seal Rock, Rhode Island, and of two reefs developed in Long Island Sound; Six Mile Reef near the middle of the sound and about 6 miles from Clinton, Conn., and Northwest Reef in the vicinity of Brandford's Reef Beacon.

No. 56 (November 15, 1884) gave the results of an examination of an uncharted shoal between the western end of L'homme Dieu Shoal, Vineyard Sound, and Nobska light-house.

No. 57 (November 15, 1884) reported the discovery of a rock in Security Bay, Chatham Strait, Alaska.

No. 58 (February 10, 1885) announced the discovery of a number of shoal spots and rocky patches in the eastern part of Long Island Sound. Also the development of Sabine Bank off the coasts of Louisiana and Texas.

No. 59 (March 23, 1885) gave directions for avoiding numerous isolated shoal patches developed in Main Ship Channel, south of Great Round Shoal, Vineyard Sound.

Nos. 60 and 61 (March 23 and June 12, 1885) gave sailing directions for and cautioned navigators against dangers in Wrangell Strait, Alaska, and similar information in regard to the Inland passage between Sitka Harbor and Hooniah Sound, through Olga Strait, Neva Strait, and Peril Straits, Alaska.

## IV.—SPECIAL SCIENTIFIC WORK.

### THE SECULAR VARIATION AND GEOGRAPHICAL DISTRIBUTION OF THE MAGNETIC DIP AND INTENSITY IN THE UNITED STATES.

In Appendix No. 6 is given an elaborate report by Assistant Charles A. Schott on the secular variation and geographical distribution of the magnetic dip and intensity in the United States. It presents a discussion of these elements, based upon a general collection of all observed values known to the author from the earliest times, and constitutes the last part of the magnetic researches respecting secular variation and distribution which for many years past have been in progress in the Survey. The secular variation and geographical distribution of the declination were discussed in papers which appeared as Appendices Nos. 12 and 13 to the Report for 1882. January, 1885, is the epoch of reduction adopted for each element.

An interesting result of the discussion of the secular variation of the dip is that Mr. Schott has been enabled to recognize and delineate a belt of "no change" for the epoch adopted, with annually increasing dip on one side and decreasing dip on the other. A similar feature was recognized in the discussion of the secular change of the horizontal intensity, the absolute measures for which date back hardly half a century.

These results, with the isoclinic and isodynamic curves, are graphically represented in the three maps and three diagrams which accompany the paper. One of these diagrams is a combination of the changes in declination and dip, showing the actual movement of a freely suspended magnetic needle for the period from 1820 to 1885.

### ADJUSTMENT AND REDUCTION OF THE DAVIDSON QUADRILATERALS.

In Appendix No. 9 are presented the results of the geodetic connection of the Yolo Base with the first side of the primary triangulation of California, forming part of what are known as the Davidson quadrilaterals. This paper, prepared by Assistant Schott, exhibits the results of the least square adjustment of a figure composed of seven stations and seventeen triangle sides, containing seventeen geometrical conditions. Sufficient detail is given to show the treatment by the Computing Division of observations of the first class, and the degree of accuracy reached in the results. It will be seen that these observations, whether compared with our own or with foreign measures, stand in the first order of precision, and they may well be taken as a piece of work representative of the accuracy attainable in modern triangulation. Respecting the analytical treatment, the subject of weights relative to the measured directions has received special attention, forming one of its distinguishing features, and the introduction of the process for the computation of the probable error of a resulting side will be found of interest.

### GEOGRAPHICAL POSITIONS AND HEIGHTS OF UPWARDS OF ONE THOUSAND STATIONS IN THE STATE OF MASSACHUSETTS, AND GEOGRAPHICAL POSITIONS OF ABOUT THREE HUNDRED STATIONS IN THE STATE OF RHODE ISLAND.

It is proposed to publish from time to time, as results become available, tables of geographical positions and heights in the several States in which the work of the survey is making progress. Appendix No. 8 contains the geographical positions and heights of upwards of one thousand stations in the State of Massachusetts and the geographical positions of about three hundred stations in the State of Rhode Island. Of the positions in Massachusetts, about one hundred were determined by the triangulation of that State executed by Simeon Borden between 1832 and 1838. A few points were established by the same triangulation in the State of Rhode Island. All of Mr. Borden's positions have been recomputed in this office in order to refer them to the standard data of the Survey.

### A PLEA FOR A LIGHT ON SAINT GEORGE'S BANK.

In Appendix No. 11, Assistant Henry Mitchell presents an urgent plea for the establishment of a light on Saint George's Bank. This great danger to seamen, lying upon the threshold of the Gulf of Maine, and 100 miles from the nearest land, is, as a shoal, far more dangerous than it would be as an island, and yet, as Mr. Mitchell observes, it is unmarked and undistinguishable except by its hideous roar when the ship is already within its breakers. As a warning and guiding mark to the ocean commerce of the Atlantic coast, and especially as a friendly signal to the fishing fleet of the Gulf of Maine, numbering at times four hundred vessels, carrying four thousand men, fishing on the Georges or crossing the shoals *en route* to more distant grounds, the benefits of such a light would be incalculable.

### COMPARISON OF TRANSVERSE SECTIONS OF THE DELAWARE RIVER BETWEEN OLD NAVY-YARD AND EAST END OF PETTY'S ISLAND, AS DERIVED FROM THE SURVEYS OF 1819, 1843, AND 1878.

The study of the changes in the channel-depths and cross-sections of Delaware River, undertaken of late years by Assistants Henry Mitchell and H. L. Marindin, is of immediate practical utility as bearing upon the effect of the construction of wharves and piers in contributing to such changes. Assistant Marindin presents in Appendix No. 12 a comparison of changes in transverse sections of that part of the river which embraces the principal part of the harbor of Philadelphia. His conclusions, as stated in the paper, and as graphically represented in the diagrams accompanying, are derived from the surveys of 1819, 1843, and 1878, and will have special value for the United States Advisory Commission on the improvement of the navigation of the Delaware.

### HARMONIC ANALYSIS OF THE TIDES AT GOVERNOR'S ISLAND, NEW YORK HARBOR.

In reports previously submitted and published as appendices to the annual reports of the Survey, the method of harmonic analysis has been applied by Prof. William Ferrel to the discussion of the tides of Penobscot Bay, of Sandy Hook, and of the Pacific coast (Appendices Nos. 11 of 1878, 9 of 1883, and 17 of 1882). The principles of this method were fully set forth, with rules, formulæ, and examples of the various reductions in the paper relating to the Penobscot Bay tides.

In Appendix No. 13 to this report is presented Professor Ferrel's paper on the harmonic analysis of the hourly co-ordinates of the heights of the tides at Governor's Island, New York Harbor, for the years 1876, 1877, and 1878. These hourly co-ordinates were measured from the curves recorded by the self-registering tide-gauge which had been maintained at that locality for many years.

Professor Ferrel remarks that there is a very great similarity between the tides at Governor's Island and those at Sandy Hook; that the amplitudes of all the separate tidal components are very nearly the same for both stations, but that, as was to be expected, the epochs at Governor's Island are somewhat greater, causing the tide to be about twenty-nine minutes later at that station than at Sandy Hook.

## EXPLANATION OF ESTIMATES.

The estimates submitted to the Department for the fiscal year 1886–1887 were accompanied by the following statement:

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
*Washington, October* 12, 1885.

SIR: I have the honor of submitting herewith the estimates of the appropriations required for the United States Coast and Geodetic Survey, for the fiscal year ending June 30, 1887, and respectfully request your approval thereof.

If it were definitely determined that the Coast and Geodetic Survey should continue to exist as a separate bureau, an immediate modification of its existing plan of organization, involving a corresponding modification in its efficiency and cost, would seem to be advisable. Such a modification should involve a reduction in the number and expense of the field, or so-called "normal force," and an increase in its efficiency by the elimination of the ineffective members, by so classifying the residue as to stimulate the junior element with a prospect of reasonably early promotion as the reward of skill and activity, and by abolishing entirely the system of payments and promotions upon the basis of longevity and putting them absolutely, as far as practicable, upon the basis of merit as indicated by the individual records of work performed.

In view, however, of the reference of matters relating to the organization of this and certain other bureaus of the Government to a joint commission appointed by Congress, and the consequent uncertainty involving the immediate future of this bureau, I have not felt warranted in attempting to anticipate Congressional action by submitting estimates predicated upon an experimental and temporary scheme of reorganization. The accompanying schedule of estimates is therefore made upon the basis of the existing plan of organization of the bureau as embodied in the Regulations for the government of the Coast and Geodetic Survey, issued from the Treasury Department February 18, 1881.

While the aggregate amount asked for, $568,060, is somewhat larger than the amount appropriated for the current year, $553,496.39, it is less by the sum of $67,510 than the amount asked for the current year. The amount asked for the various classes of field-work is $32,800 more than the amount appropriated for that class of work for the current year, while the amount asked for pay of field officers, office force, and office expenses is $18,236.39 less than the amount appropriated for the current year for those items of expense. In other words, the estimates now submitted contemplate the performance of more work at a less cost for salaries and office expenses than was practicable under the appropriations for the current year.

The estimates for "Party Expenses," including work of Furnishing points for State surveys, for Transcontinental Geodetic work, and for Resurveys of New York Harbor and San Francisco Bay, &c., cover the pay of those temporarily employed as recorders, signal-men, hands, cooks, drivers, or boatmen, or in any other capacity except as members of the permanent or normal force; the subsistence of the chiefs and employés of parties; traveling expenses to and from the field, and local transportation in the vicinity of field work; the transportation of instruments, tents, stationery, materials, outfit, and equipage to and from the field and in the field; and the purchase of all requisite materials, supplies, tents, boats, stationery, camp equipage, and all other necessary expenses properly incident to the prosecution of the work in the field.

An increase of the appropriation for "Party Expenses," as compared with the appropriations under that head for the current year, is, I believe, absolutely necessary to "a proper economic proportion between the expense of putting the various parties in the field and the length of time that they can be kept at work." After deducting from each appropriation for specific work the expense of transporting the field party and equipage to and from the locality of that work, the balance of the appropriation measures the amount of effective field work capable of being done. To so stint the appropriation as to compel the withdrawal of parties from the field before the expiration of the season favorable to effective work, shortens the period of active work, lengthens the period of comparative idleness, increases the aggregate cost, and delays the final completion of the work, and is therefore a measure of false economy.

In conformity with the views of Congress as indicated in the appropriation for the current year, the estimates are itemized for the various purposes mentioned. Under that form of appropriation, the degree of caution necessary to avoid incurring deficiencies compels the withdrawal of parties from the field before the amounts appropriated for their respective schemes of work are expended. This results in the untimely interruption of much of the work, and in the creation of unexpended balances available for no purpose in the promotion of the business of the Bureau, unless a sufficient proportion of the appropriations can be made interchangeable to cover deficiencies resulting from the continuance of field work in some localities as long as favorable climatic conditions justify it. The ten per centum of interchangeability of the appropriations for the current fiscal year does not afford a sufficient margin to enable the Superintendent to adapt the expenditures and the field-work to the varying conditions of the various localities, and so to produce the best results from the amounts expended. It is therefore earnestly hoped that upon that point the suggestion of the estimates may be incorporated into the appropriation act and 20 per cent. of the amounts appropriated for "party expenses" be made available interchangeably for expenditure on the objects named.

In making estimates for salaries, the phrase "not exceeding" is employed with the purpose of determining their maximum, leaving without apparent limitation the authority of the Secretary of the Treasury or the Superintendent to reduce any of them in his discretion.

In apportioning the amounts asked for, the idea of prosecuting the survey of the coasts—the original purpose of this Bureau—to an early completion has been kept constantly in view.

In recognition of the practical value of geodesy to exact results in surveys of the public domain, as well as with a view to the maintenance of the honorable distinction achieved by this country in the scientific world, the estimate is somewhat increased beyond the amount appropriated for the current year for geodetic work, the scientific importance of which has enlisted in its prosecution abroad an association of the leading Governments of Europe.

It is hoped that the amount asked for resurvey of New York Harbor will be sufficient to complete the work, the progress of which during the current year has developed several dangers to navigation in those waters.

Included in the estimates is the sum of $30,000 for the resurvey of San Francisco Bay and of the Straits of Karquines, and examination of San Francisco Bar and entrance, and of the mouths of the Sacramento and San Joaquin Rivers. The importance of these waters to the great commerce of the Pacific, and the marked changes constantly occurring in their character since the former surveys were concluded, which changes are largely due to the deposits of débris from hydraulic mining and from the heavy freshets to which the rivers mentioned are subject, render such resurvey highly desirable.

Very respectfully,

F. M. THORN,
*Superintendent.*

The Hon. SECRETARY OF THE TREASURY,
*Washington, D. C.*

ESTIMATES.

For every expenditure requisite for and incident to the survey of the Atlantic, Gulf, and Pacific coasts of the United States, 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; a magnetic map of North America; and including compensation, not otherwise appropriated for, of persons employed in 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 allowance for subsistence to officers of the Navy attached to the Survey, not exceeding one dollar per day, as allowed by act of Congress approved June 12, 1858, and including traveling expenses of officers and men of the Navy on duty; the outfit, equipment, and care of vessels used in the Survey; and also the repairs and maintenance of the complement of vessels, to be expended under the following heads:

FOR PARTY EXPENSES:

| | |
|---|---|
| For continuing the survey of the coast of Maine eastward from Machias Bay towards Quoddy Head | $12,000 |
| For examination of reported dangers and changes on the eastern coast | 1,000 |
| For continuing resurvey of Long Island Sound and finishing same | 20,000 |
| For completing resurvey of Delaware Bay, including current observations | 2,000 |
| For continuing examination of changes and resurveys on the sea-coast of New Jersey | 2,000 |
| For continuing examinations and surveys of estuaries of Chesapeake Bay, and of Sounds and tide-water passages in North and South Carolina not heretofore surveyed | 4,000 |
| For continuing the survey of the western coast of Florida from Estero Bay southward and from Saint Joseph's Bay northward, and hydrography of the same | 10,000 |
| For continuing the survey of the coast of Louisiana west of the Mississippi Delta, and hydrography on the coasts of Louisiana and Texas | 5,000 |
| To make off-shore soundings along the Atlantic coast and current and temperature observations in the Gulf Stream | 9,000 |
| For surveys and examinations of Monomoy Shoals, Nantucket Sound | 2,000 |
| For continuing the researches in physical hydrography relating to harbors and bars | 2,000 |
| For determinations of geographical positions (longitude party) | 5,000 |
| To continue the primary triangulation from Atlanta towards Mobile | 8,000 |
| To continue the primary triangulation between Charleston, S. C., and the northwest corner of the State to connect with the oblique arc along the Blue Ridge | 2,000 |
| For continuing an exact line of levels from the Gulf to the transcontinental line of levels between the Atlantic and Pacific Oceans, and for continuing the transcontinental line of levels | 4,000 |
| To continue tide observations on the Atlantic coast | 2,000 |
| To continue magnetic observations on the Atlantic and Gulf coasts | 1,000 |
| 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 | 3,500 |
| To continue the compilation of the Coast Pilot, and to make special hydrographic examinations for the same | 2,500 |
| For continuing the topographical survey of the coast of Southern California | 6,000 |
| For continuing the primary triangulation of California | 12,000 |
| For continuing the survey of the coast of Oregon, including off-shore hydrography, and to complete the survey of the Columbia River and Willamette River to the head of ship navigation | 12,000 |
| For continuing the survey of the coast of Washington Territory | 9,500 |
| For continuing explorations in the waters of Alaska and making hydrographic surveys in the same | 12,000 |
| 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 |
| For continuing tide observations on the Pacific coast | 2,500 |
| For magnetic observations on the Pacific coast | 2,000 |

| | |
|---|---|
| For traveling expenses of the Superintendent and his party on duty of inspection... | $600 |
| For objects not hereinbefore named that may be deemed urgent .................. | 4,000 |
| And twenty per centum of the foregoing amounts shall be available interchangeably for expenditure on the objects named. | |
| In all, for party expenses ............................................ | 160,600 |
| FOR FURNISHING POINTS FOR STATE SURVEYS ................................ | 10,000 |
| FOR TRANSCONTINENTAL GEODETIC WORK ..................................... | 36,000 |
| For continuing resurvey of New York Bay and Harbor, including East River, to Throg's Neck ............................................ | 8,000 |
| For resurvey of San Francisco Bay and of San Pablo and Suisun Bays and the Strait of Carquinez, and examination of San Francisco Bar and entrance, and the mouths of the Sacramento and San Joaquin Rivers ............................ | 30,000 |
| FOR PAY OF FIELD OFFICERS: | |
| For pay of Superintendent at not exceeding $6,000 per annum .................. | 6,000 |
| For pay of one Assistant in charge of Pacific coast operations, at not exceeding $4,000 per annum ............................................ | 4,000 |
| For pay of two Assistants at not exceeding $3,500 per annum each .............. | 7,000 |
| For pay of two Assistants at not exceeding $2,800 per annum each .............. | 5,600 |
| For pay of four Assistants at not exceeding $2,500 per annum each ............. | 10,000 |
| For pay of five Assistants at not exceeding $2,300 per annum each ............. | 11,500 |
| For pay of six Assistants at not exceeding $2,200 per annum each .............. | 13,200 |
| For pay of seven Assistants at not exceeding $2,000 per annum each ............ | 14,000 |
| For pay of ten Assistants at not exceeding $1,800 per annum each .............. | 18,000 |
| For pay of nine Assistants at not exceeding $1,500 per annum each ............. | 13,500 |
| For pay of three Subassistants at not exceeding $1,400 per annum each ......... | 4,200 |
| For pay of two Subassistants at not exceeding $1,300 per annum each ........... | 2,600 |
| For pay of four Subassistants at not exceeding $1,100 per annum each .......... | 4,400 |
| For pay of eight Aids at not exceeding $900 per annum each .................... | 7,200 |
| For pay of one Aid at not exceeding $720 per annum ............................ | 720 |
| Total for pay of field officers ............................................ | 121,920 |
| FOR PAY OF OFFICE FORCE: | |
| For one Disbursing Agent at not exceeding $2,000 per annum .................... | 2,000 |
| For four Clerks at not exceeding $1,800 per annum (one to act as Librarian) ....... | 7,200 |
| For one Clerk at not exceeding $1,500 per annum ............................... | 1,500 |
| For eight Clerks at not exceeding $1,000 per annum each ....................... | 8,000 |
| For nine Clerks at not exceeding $800 per annum each .......................... | 7,200 |
| For two Computers at not exceeding $1,850 per annum each ...................... | 3,700 |
| For one Computer at not exceeding $1,800 per annum ............................ | 1,800 |
| For one Computer at not exceeding $1,500 per annum ............................ | 1,500 |
| For one Computer at not exceeding $1,400 per annum ............................ | 1,400 |
| For two Computers at not exceeding $1,300 per annum each ...................... | 2,600 |
| For two Computers at not exceeding $1,000 per annum each ...................... | 2,000 |
| For three Engravers at not exceeding $2,000 per annum each .................... | 6,000 |
| For two Engravers at not exceeding $1,800 per annum each ...................... | 3,600 |
| For three Engravers at not exceeding $1,500 per annum each .................... | 4,500 |
| For one Engraver at not exceeding $900 per annum .............................. | 900 |
| For one Contract Engraver, contract not to exceed $2,400 per annum ............ | 2,400 |
| For one Contract Engraver, contract not to exceed $2,100 per annum ............ | 2,100 |
| For one Contract Engraver, contract not to exceed $1,800 per annum ............ | 1,800 |
| For one Contract Engraver, contract not to exceed $800 per annum .............. | 800 |

| | |
|---|---|
| For four Draughtsmen at not exceeding $2,000 per annum each | $8,000 |
| For two Draughtsmen at not exceeding $1,800 per annum each | 3,600 |
| For one Draughtsman at not exceeding $1,500 per annum | 1,500 |
| For three Draughtsmen at not exceeding $1,400 per annum each | 4,200 |
| For two Draughtsmen at not exceeding $1,300 per annum | 2,600 |
| For one Draughtsman at not exceeding $1,200 per annum | 1,200 |
| For one Draughtsman at not exceeding $1,100 per annum | 1,100 |
| For one Draughtsman at not exceeding $900 per annum | 900 |
| For one Electrotypist and Photographer at not exceeding $1,600 per annum | 1,600 |
| For one Assistant Electrotypist and Photographer at not exceeding $1,150 per annum | 1,150 |
| For one Apprentice to Electrotypist at not exceeding $360 per annum | 360 |
| For one Head Watchman and Janitor at not exceeding $1,200 per annum | 1,200 |
| For two Watchmen at not exceeding $800 per annum each | 1,600 |
| For one Messenger at not exceeding $800 per annum | 800 |
| For three Messengers at not exceeding $600 per annum | 1,800 |
| For three Messengers at not exceeding $500 per annum | 1,500 |
| For one Driver at not exceeding $600 per annum | 600 |
| For two Packers and folders at not exceeding $600 per annum each | 1,200 |
| For four Laborers at not exceeding $550 per annum each | 2,200 |
| For two Laborers at not exceeding $360 per annum each | 720 |
| For one Fireman at not exceeding $650 per annum | 650 |
| For one Fireman at not exceeding $500 per annum | 500 |
| For one Map-mounter at not exceeding $1,000 per annum | 1,000 |
| For one Map-mounter at not exceeding $360 per annum | 360 |
| For one Carpenter at not exceeding $1,500 per annum | 1,500 |
| For one Carpenter at not exceeding $700 per annum | 700 |
| For one Carpenter at not exceeding $500 per annum | 500 |
| For two Mechanicians at not exceeding $1,500 per annum each | 3,000 |
| For two Mechanicians at not exceeding $1,300 per annum each | 2,600 |
| For one Mechanician at not exceeding $800 per annum | 800 |
| For one Mechanician at not exceeding $500 per annum | 500 |
| For one Copper-plate Printer at not exceeding $1,600 per annum | 1,600 |
| For three Copper-plate Printers at not exceeding $1,200 per annum each | 3,600 |
| For two Copper-plate Printers at not exceeding $700 per annum each | 1,400 |
| Total for pay of office force | 117,540 |

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, and charts | 12,000 |
| For copper-plates, chart-paper, printers' ink; copper, zinc, and chemicals for electrotyping; engravers' and printers' supplies; for extra engraving; and for photolithographing charts for immediate use | 11,500 |
| For stationery for the office and field parties; transportation of instruments and supplies; office wagon and horses; fuel; gas; telegrams; ice; washing; and extra labor | 8,000 |
| For miscellaneous expenses, contingencies of all kinds, office furniture and repairs, and for traveling expenses of Assistants and others employed in the office sent on special duty in the service of the office | 4,000 |
| Total for office expenses | 35,500 |

| | |
|---|---|
| FOR 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 |
| Total for rent of office buildings ........................................ | 16,500 |
| FOR PUBLISHING OBSERVATIONS.—For continuing the publication of observations and their discussion made in the progress of the Coast and Geodetic Survey, including compensation of civilians engaged in the work, the publication to be made at the Government Printing Office ........................................ | 6,000 |
| FOR REPAIRS AND MAINTENANCE OF VESSELS.—For repairs and maintenance of the complement of vessels used in the Coast and Geodetic Survey, including the outfit, equipment, and care of the same ........................................ | 26,000 |
| Total amount estimated for United States Coast and Geodetic Survey for 1886–'87 | $568,060 |
| Amount appropriated for the fiscal year ending June 30, 1886 ................ | $553,496.39 |

# PART II.

This part of the report is occupied by statements in detail of operations afield and afloat, and by a summary of the work of the office. Its arrangement under the heads of sections is the same as that heretofore adopted. Appendix No. 1 presents in a geographical order the distribution of the field parties; in Appendix No. 4 is given the report of the Assistant in charge of the office.

The direction of office operations was continued during the year with Assistant Charles O. Boutelle, whose assignment to that duty dates from January, 1884. Much of the time that he could spare from administrative work was devoted to the arrangement and preparation for publication of a new and enlarged edition of the projection tables, the computations for which were made under his personal supervision. These tables were published as Appendix No. 6 to the Report for 1884, and supersede all former projection tables published by the Survey.

Commander C. M. Chester, U. S. N., remained on duty as Hydrographic Inspector during the year. He had charge of the details of all hydrographic work, acting as chief adviser and executive officer of the Superintendent in matters pertaining to hydrography. As Inspector of Hydrography, and as in charge of the repairs and maintenance of the vessels of the Survey, his duties are in the field as well as in the office. The general charge of the Coast Pilot Division of the office is committed to him, as also the supervision of the labors of the office hydrographic draughtsmen.

In Appendix No. 5 is given in full Commander Chester's annual report, in which, in anticipation of his relief from the Coast and Geodetic Survey service, after having been connected with it for eight years, including five years duty as Hydrographic Inspector, he expresses his regret at severing personal relations of so pleasant a character and his sense of obligation for many courtesies received from his associates in the Survey. The Superintendent takes this occasion to express his high appreciation of the value of the services of this able and accomplished officer, and to say that it will not be easy to replace the professional skill and sound judgment, ripened by experience, which he has brought to the conduct of the work.

Administrative details in the Hydrographic Division were wholly in charge of Lieut. Jefferson F. Moser, U. S. N., Assistant Coast and Geodetic Survey, under whose direction Commander Chester reports that the best results possible are obtained. In December, 1884, Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, who had been in immediate charge of the Coast Pilot Division, was relieved and transferred to the command of the steamer Blake. At the end of the fiscal year, Lieut. G. H. Peters, U. S. N., Assistant Coast and Geodetic Survey, was assigned in place of Lieutenant Pillsbury.

Mr. Edward H. Wyvill served acceptably as clerk in the Hydrographic Division; Messrs. E. Willenbucher, W. C. Willenbucher, and F. C. Donn as draughtsmen.

## 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.)

*Topography of Machias Bay entrance, Machiasport and the coast to the eastward.*—In continuation of the topographical survey of the coast of Maine in the vicinity of Machias Bay, Assistant Charles H. Boyd organized his party in June, 1884, and began the filling in of topographical details upon the plane-table sheets of Machias Bay entrance and Machiasport. The bay and ocean shore-line upon these sheets had been laid down during a previous season.

Villages, farm lands, rocky hills, and extensive tracts of dense forests are the leading characteristics of the topography, which lies within the towns of Machiasport, East Machias, Whiting, and Cutler.

Mr. Boyd mentions, as matter of historical interest, that the ruins of an old trading post and block-house are still in existence a short distance north of Battery O'Brien, on Fort Point. They mark a site first occupied by Richard Vines, who in 1633 purchased of the Plymouth Council the exclusive right to trade with the natives of these coasts. In July, 1775, the Council of Safety ordered the mouth of the river to be fortified, and this fort, known as Fort O'Brien, was then garrisoned, and again in 1812. In 1862 an earthwork and magazine were built here, which are even now in a condition to be easily made serviceable.

At the "Rim," a long narrow point between the two branches of the Machias River, are the ruins of an old earthwork, known as Fort Foster. This was captured in August, 1777, by an English squadron under Sir George Collier.

Field operations were closed upon the completion of the sheets in October.

Mr. Henry R. Taylor, of Machias, served very acceptably during the season. The statistics of the work, which was on a scale of 1–10000, are as follows:

| | |
|---|---|
| Miles of roads surveyed | 47 |
| Miles of creeks surveyed | 7 |
| Area of survey in square miles | 20 |

Mr. Boyd is under instructions to resume the survey in this vicinity, and organized his party for that purpose in June, 1885.

During part of the winter he was on special duty in charge of the Coast and Geodetic Survey exhibit at the New Orleans Exposition.

*Topography of Chandler's Bay and Englishman's Bay, coast of Maine.*—Work upon the topographical sheet of Chandler's River and Bay, which had been begun by Assistant Eugene Ellicott in 1882, was resumed by him under instructions dated in July, 1884, and the sheet was finished about the end of August. The survey of the shore-line of Englishman's Bay, just west of Machias Bay, was then taken up and prosecuted to the close of the season.

Included in this sheet are the shore-lines of Rogue Island, Great Spruce Island, and Halifax Island, special care having been taken to determine the limits of low-water mark on these shore-lines.

Field operations were closed, and the party disbanded at the close of October. Mr. Ellicott refers in terms of marked approval to the services of Mr. J. H. Turner, aid in his party.

The statistics of the work, scale 1–10000, are as follows:

| | |
|---|---|
| Miles of shore-line surveyed | 51 |
| Miles of road | 20 |
| Area surveyed in square miles | 14 |

Duty subsequently assigned to Mr. Ellicott is referred to under the headings of Sections III and VI of this report. Towards the close of the fiscal year he was directed to take up and complete the topography of the shores of Englishman's Bay, and then to continue the survey to the eastward of Machias Bay.

*Hydrographic survey of Narraguagus River from Millbridge to Cherryfield; of Harrington River, including Flat and Back Bays, and of Pleasant River to Addison.*—In July, 1884, Lieut. E. D. F. Heald, U. S. N., Assistant Coast and Geodetic Survey, having, in pursuance of instructions, organized his party on board the schooner Eagre, began a series of hydrographic surveys to fill up gaps in previous work, and complete the hydrography in the vicinity of Narraguagus and Pleasant Bays. For this purpose he was furnished with three projections: one for the Narraguagus River from Millbridge to Cherryfield; one for Harrington River from its mouth to Harrington, taking in also Flat and Back Bays, and one for Pleasant Bay and River to Addison.

In Narraguagus River, zigzag lines were run about one hundred meters apart, the beginning and ending of nearly all of the lines being determined by shore signals, and all lines run on ranges. This work completed the survey of Narraguagus River.

On the sheet of Harrington River, two sets of lines were run, one in the direction of and one normal to the course of the stream and about one hundred meters apart, except in Flat and Back Bays, where the system was opened to two hundred meters, and in the narrow part of the river, near Harrington, where zigzag lines were run. This survey was completed and connected with the work of 1883.

Lieutenant Heald observes that Flat and Back Bays and the narrow part of Harrington River are almost completely bare at low water. An excellent channel was found through what is known as Dyer's Island Narrows, or the Eastern Passage, which if properly buoyed could be navigated by coasting steamers at any stage of the tide. The buoys as placed at the time of the survey of Lieutenant Heald he found to mark a course that was not safe at low water.

Owing to the advance of the season it was not found practicable to finish the work on the sheet of Pleasant Bay and River, and the limit for closing was fixed at the line joining the river and bay. The survey of the bay was completed, and joins with previous surveys in this locality. Lines were run as on the sheet of Harrington River, one hundred meters apart, except in the deep part of the bay, where no evidence of shoal water could be found, when the system was opened to two hundred meters.

To determine a plane of reference for the soundings, tidal observations were made at the steamboat wharf, Millbridge, Narraguagus Bay.

In his report, Lieutenant Heald takes occasion to express for himself and for the officers who were associated with him the great satisfaction and pleasure they derived from the extremely accurate delineation of shore-line as given on their projections from the work of the topographical parties of the Survey.

Additional soundings and hydrographic examinations having been found necessary off Great Wass Island and Jordan's Delight Ledge, Lieutenant Heald was directed to make these on closing work in Pleasant Bay. This duty having been satisfactorily performed, he proceeded with the vessel and party to New York, where he arrived November 16.

Ensigns T. D. Griffin, A. Jeffries, and W. C. Canfield, U. S. N., were attached to the Eagre during the season.

The statistics of the hydrographic work, which was executed on a scale of 1–10000, are as follows:

| | |
|---|---|
| Miles run in sounding | 548 |
| Angles measured | 7,575 |
| Number of soundings | 44,518 |

Reference is made under the headings of Sections VI and VIII to duty subsequently assigned to Lieutenant Heald in southern waters.

*Topographical Survey in the vicinity of Prospect Harbor, Gouldsborough, Me., and resurvey of Bar Harbor, Mount Desert Island, Maine.*—The field-work of the topographical party in charge of Assistant A. W. Longfellow, during the summer and autumn of 1884, consisted in adding details of topography to complete the topographical sheet of Prospect Harbor, Gouldsborough, Me., and in a resurvey of Bar Harbor, Mount Desert Island, Maine.

Assistant E. F. Dickins was directed to report to Mr. Longfellow for duty, and joined his party July 22. From that date till the close of the season, November 10, Mr. Dickins was actively engaged in the field. He finished the plane-table survey of Prospect Harbor September 15, and then took up the resurvey of Bar Harbor. It had been at first intended to add the new streets, houses, &c., to the topographic sheet of 1873, but the growth of the town had been so extensive that this was found to be hardly practicable. The houses had increased since the former survey from one hundred and fifty to upwards of seven hundred, and the new villas built upon the hillsides afforded conspicuous landmarks to the navigator.

Upon the completion of field-work, Assistants Longfellow and Dickins repaired to Portland, where tracings were made of the plane-table sheets. Mr. Dickins was detached from the party and ordered to duty at the Office towards the end of November. In his report of the season's operations, Mr. Longfellow acknowledges the great value of Mr. Dickins's services in both field and office work.

*Record of observations with self-registering tide-gauge continued and meteorological observations recorded at Pulpit Cove, North Haven Island, Penobscot Bay.*—It is satisfactory to note that but a few years more of continuous record will be needed to complete a lunar cycle of one of the most perfect series of tidal observations obtained upon the Atlantic coast. No interruption has occurred in this series since it was begun by the present observer, Mr. J. G. Spaulding, in January, 1870. The locality, Pulpit Cove, sometimes called North Harbor, on the north side of North Haven Island, Penobscot Bay, was selected as one of the most favorable for the purpose in view, a thorough investigation of the laws of tidal action in the Gulf of Maine. Data derived from these observations were made the basis of Professor Ferrel's discussion of the tides in Penobscot Bay (Appendix 11, Report for 1878) and afforded valuable material to Assistant Mitchell for his paper on the Physical Hydrography of the Gulf of Maine (Appendix 10, Report for 1879).

*Hydrographic examinations off the coasts of Maine, New Hampshire, and Massachusetts.*—Certain dangers to navigation not laid down on the charts having been reported off the coasts of Maine, New Hampshire, and Massachusetts, Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, was instructed at the beginning of the fiscal year to make search for and locate them.

His examinations off York Harbor, Maine, North Hampton, N. H., in the vicinity of Marblehead Rock, Massachusetts, and off Nahant, resulted in the publication of a Notice to Mariners in October, 1884, in which were given warnings of the following dangers:

I.—A rock reported off York, Me., on which the steamer City of Portsmouth struck, was found to have a depth of seven and one-half feet over it, and situated on the following bearings:

Cape Meddick Light-House, NE. $\frac{1}{8}$ E., distant two and one-fourth miles.

Extremity of East Point, NW. $\frac{1}{8}$ W., distant three hundred and thirty yards.

Boon Island Light-House, ESE. $\frac{1}{4}$ E., distant six and one-fourth miles.

It is surrounded by other rocks, with depths from fourteen to eighteen feet, the outer one being marked by a buoy.

II.—A vessel was reported to have struck an unknown rock between Marblehead Rock and Marblehead Neck. In an examination of the vicinity a small bowlder was found on the ledge, already known to exist, and shown on the charts of Salem Harbor. On this bowlder there is seven and one-half feet, and it is situated about seventy-five yards from the nearest point of Marblehead Rock, with the Lowell (or Cat) Island Beacon just open of its northern point. Vessels keeping the middle of the passage will clear all dangers.

III.—Flip Rock, off Bass Point, Nahant, Massachusetts, reported by Mr. Edward W. Codman, was found to be a ledge about forty yards in length, having a least depth of thirteen and one-half feet at its shoalest point, and located on the following bearings:

Shag Rocks (Southeast Point) NE. by E. $\frac{3}{4}$ E., distant one and one-eighth miles.

Bass Rock Spindle, N. by E. $\frac{1}{4}$ E. five-eighths mile.

Boston Light-House, S. $\frac{5}{8}$ E., four and three-fourths miles.

To clear this rock, if wishing to pass between it and Nahant, when abreast Shag Rocks, steer about SW. by W. for the large buildings on Deer Island. When Bass Point bears NW. one-half W., steer for it, being careful not to bring it to bear to the northward of NW. by N. until up with Bass Rock Spindle.

To pass to the southward of Flip Rock, do not bring Bass Point to bear to the westward of N. by W. one-half W. until the Shag Rocks bear ENE.

All bearings in the above Notice, as in all similar ones published by this Office, are magnetic, all distances in nautical miles, and all depths at mean low water.

Hydrographic duty performed by Lieutenant Pillsbury under subsequent assignment is referred to under the heading of Section VI.

*Continuation of the triangulation of the State of New Hampshire.*—The mountain station Pequawket, sometimes known as Kearsarge North, was occupied by Prof. E. T. Quimby, Acting Assistant, at the beginning of the fiscal year in continuation of geodetic operations in the State of New Hampshire. Pequawket is about four miles from the village of North Conway, in the White Mountain region. Professor Quimby decided, upon an examination of the road up the mountain, that it was quite out of the question to attempt to establish his camp near the summit; hence the instruments and observing tent were sent to the top, while camp was pitched at the base, three miles from the station. The top of the mountain having been a favorite resort for tourists for thirty years, a hotel had been kept there, and the cupola of this house had been observed upon in the progress of the triangulation.

In November, 1883, a severe gale completely demolished the hotel and scattered its fragments far down the mountain. The removal of the house did not, however, prove to be of so much advantage as was at first anticipated, since the point on the ground corresponding to the center of the cupola was too low to afford an unobstructed view of the horizon. Almost immediately upon the arrival of the party the erection of another hotel had been begun, and this was pushed forward so rapidly as soon to obstruct three of the lines of sight from the point which was selected as a temporary station. A second position was therefore occupied which was adopted as the true station, and the observations taken from various points upon the old house cupola were reduced to the true station, with reference to which were determined the positions of the first or eccentric station, and of the chimney of the new house.

Upon the completion of the observations of Pequawket, in September, Professor Quimby went to Trask Hill, thirty miles to the southward, to measure a horizontal direction, and then visited several points in Rockingham County, among them Garrison Hill, in Dover. He found that it would be necessary to occupy an eccentric station here during the next season, the tower on the hill, upon which observations had been made from other points, not being suitable for occupation with the theodolite.

The following are the statistics of the season's work:

| | |
|---|---|
| Number of horizontal directions determined | 164 |
| Number of vertical angles measured | 14 |

*Stations occupied for continuing the triangulation of the State of Vermont.*—Two stations were occupied by Prof. V. G. Barbour during the summer and autumn of 1884 for the extension of the triangulation of the State of Vermont. On July 11 he established his party at station Gile, in the northern part of the town of Norwich, Windsor County. The necessary signals having been erected, one of them on Cube Mountain, in New Hampshire, and one on Ascutney Mountain, Vermont, and lines of sight opened, the horizontal direction of seven stations was determined by the 1st of August. Gile, being near the boundary line between New Hampshire and Vermont, was one of the stations observed upon by Professor Quimby from points in New Hampshire, and had been occupied by him previously to its occupation by Professor Barbour. It was found necessary therefore to observe upon but two of the New Hampshire stations, Cube and Corydon.

Station Cotton, in the town of Vershire, Orange County, was the next point occupied. Signals were erected on Moos-i-lauk and Bald Ledge, in New Hampshire, and on Potato Hill, in Vermont. The weather at this station being unfavorable, observations were somewhat delayed, but were finished September 12, the party being disbanded a few days later.

*Trigonometrical operations in aid of a topographical survey of the State of Massachusetts.*—The service rendered by Assistant Henry L. Whiting, under special assignment, as a member of the board of harbor and land commissioners of the State of Massachusetts, has been referred to in previous volumes of these reports. This special duty ceased at the close of the fiscal year with the expiration of Mr. Whiting's appointed term of three years' service on that board.

In June, 1884, plans were matured for a topographical survey and map of the State of Massachusetts, to be executed by the State in co-operation with the Geological Survey, and Mr. Whiting was appointed by the Governor one of three Commissioners to arrange the form and all details of the work on behalf of the State. His associates in this duty were President Francis A. Walker, of the Massachusetts Institute of Technology, and Prof. N. S. Shaler, of Harvard College. With the consent of the Secretary of the Treasury Mr. Whiting was authorized to accept this appointment, and was elected secretary of the Commission.

Application having been made by the Commission to this office to supply such additional triangulation in the State as might be needed for the proper execution of the topographical survey, Assistant Gershom Bradford reported under instructions to Mr. Whiting in September, and continued in the field in Southeastern Massachusetts until the 4th of December. During this time he reproduced ten of the points of a former triangulation by the Coast Survey, and five points of the Borden State survey made forty years ago, besides determining twelve new triangulation points, making twenty-seven points in all available for the topography.

Special appropriation was made by the State legislature, and approved March 27, 1885, for the cost of determining by triangulation the boundary line of the cities and towns in the Commonwealth under the direction of the Commissioners. Under application, duly made, two officers of the Coast and Geodetic Survey were detailed, with instructions to report to Mr. Whiting. Assistant F. W. Perkins was assigned to continue the determination of points for the State survey, and Subassistant C. H. Van Orden to the work of determining the boundary lines of cities and towns.

At the close of the fiscal year Mr. Perkins was occupied in furnishing triangulation points to the topographical party at work in the valley of the Connecticut River, while Mr. Van Orden took up a working ground with Boston as a center.

Mr. Whiting's duties under instructions in the Coast and Geodetic Survey, and as the executive member of the State Commission, have required his constant attention in the intervals of field work as well as during the season of its active prosecution.

*Hydrographic examinations off the coasts of Massachusetts and Rhode Island.*—In October, 1884, Lieut. Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Blake, was directed to make certain hydrographic examinations in Vineyard Sound, Narragansett Bay, and Block Island Sound, with reference to the existence of dangers to navigation reported as not laid down on the charts.

The locality of his first examination was in Vineyard Sound, between the western end of L'Homme Dieu Shoal and Nobska light-house. Information had been received at this office from Captain Wright, of the schooner Kate Gifford, through the Hydrographic Office of the Navy Department, of the existence of an uncharted shoal in this vicinity. Lieutenant-Commander Brownson found two lumps to the westward of L'Homme Dieu Shoal, about five-eighths of a mile distant, and situated on the following bearings:

Nobska light-house, W. ¾ N., two and three-fourths miles.

Holmes's Hole (West Chop) light-house, S. by W. ½ W. westerly, two and three-eighths miles.

East Chop light-house, S. by E., three and one-eighth miles.

The least water found over the lumps was twelve feet. There is deep water around them.

In the Notice to Mariners, which was promptly issued, the following directions were given:

To avoid this shoal in approaching from the eastward, continue on the course W. ¾ N. from Succonesset Shoal light-vessel until West Chop light-house bears S. by W. ½ W., then change course to SW. by W. ¼ W. for two miles, when Nobska light-house will bear NW. by W. The usual sailing line may then be followed.

In this Notice, as in all similar ones published by this Office, all bearings are magnetic and all distances in nautical miles. When depths are given they are at mean low water.

Examination of a shoal spot near Lucas Shoal, Vineyard Sound, led to the discovery of a small lump with thirteen and a half feet upon it at low water, and three hundred feet SW. by W. ¼ W. (mag.) of Lucas Shoal. To have this lump well marked, the buoy was moved a short distance to the westward, as recommended by Lieutenant-Commander Brownson.

Early in November a rock reported near Gould Island, Sakonnet River, Rhode Island, was searched for. A ledge was found about ninety feet in length and thirty feet in width, lying in a W. by S. and E. by N. direction (mag.), with from two to nine feet on it at low water, and with deep water all around. This ledge bears W. ¾ N. (mag.) from the north end of Gould Island, distant about six hundred feet. It ies on SW. ⅝ S. (mag.) bearing from the draw in the Stone Bridge. If it were buoyed on the eastern end, there would be plenty of room to pass between it and the island. The search for this ledge was conducted by Ensign William Truxtun.

On the 8th of November an examination made by Ensigns Edward Simpson and Miles Gorgas showed the existence of a rocky ledge two hundred and twenty-eight feet long and about nine feet wide S. 35° 45′ W. (mag.) from the light-house on Dutch Island, Narragansett Bay. The outer end of the ledge is two hundred and eighty-five feet from high-water mark and four hundred and five feet from the light-house. For a distance of seventy-eight feet the inner end of this ledge is awash at low water, then gradually deepening for one hundred and fifty feet to sixteen feet, and fifteen feet further off dropping down to four fathoms. The light-house keeper stated that during the past year eight schooners had struck on this ledge. During the flood-tide any vessel working in or out of Dutch Island Harbor is in danger of being set down on it. A buoy has since been placed to mark its outer edge.

Further examinations made by Lieutenant-Commander Brownson in Narragansett Bay and Block Island Sound led to the publication of a Notice to Mariners embodying the results, as follows:

(1) Shoaler water than that given on Coast and Geodetic Survey charts was found near Warwick, R. I., a patch with a least depth of seventeen feet being located S. $\frac{1}{8}$ W. two and three-fourths miles from the light-house.

An examination of the waters off the upper end of Conanicut Island also showed a slight shoaling in patches of from one to three feet, the least found being eighteen feet, one-half a mile to the northward of North Point.

(2) In the vicinity of Point Judith several irregular rocky patches were found, having from three and one-half to four and three-fourths fathoms of water over them. These shoals extend around the point from NE. by E. $\frac{1}{2}$ E. to SW. $\frac{1}{4}$ W., with a radius of seven-eighths of a mile, except to the southward and eastward of the point, where the radius is one-half mile.

(3) A rocky patch with a least depth of sixteen feet was developed three-fourths of a mile W. $\frac{1}{4}$ N. from Constellation Rock, entrance to Gardiner's Bay, on the following bearings:

Plum Island light-house, W. $\frac{3}{4}$ N., three and three-fourths miles.

Little Gull Island light-house, NE. $\frac{3}{4}$ N., two and one-eighth miles.

Gardiner's Island light-house, SW. by S., two and one-eighth miles.

Vessels of deep draught are cautioned against attempting to pass between Bedford Reef and Constellation Rock, as the intermediate bottom is irregular, with depths varying from seventeen feet to four fathoms.

Reference was made in my last annual report to surveys made by Lieutenant-Commander Brownson which developed changes in main Ship-Channel, Vineyard Sound, the existence of numerous isolated shoal patches with a least depth of seventeen feet having been shown to the south of Great Round Shoal.

The Light-House Board having rebuoyed the channel, a Notice to Mariners was published by this office, in which were given the following directions for entering:

Bring Sankaty Head light to bear SW. $\frac{1}{4}$ S., and steer for it until Nantucket light bears W. $\frac{1}{2}$ N. Head for this light on the course given until past the range of Shovelful light-vessel on with Monomoy Point light, when head for Handkerchief light-vessel on a NW. $\frac{1}{2}$ N. course. Continue on this latter course for about three miles, or until Nantucket light bears SW. by W. $\frac{3}{4}$ W., when take a mid-channel course of WNW. $\frac{3}{4}$ W. for Cross Rip light-vessel. The least depth of water on these sailing lines at date of survey was five and a half fathoms.

The following-named officers served in the party on the Blake during the season of 1884: Lieut. F. H. Crosby, U. S. N., Ensigns P. J. Werlich, William Truxtun, E. Simpson, jr., and M. C. Gorgas, U. S. N.

Upon closing work about the end of November, the Blake was taken to New York, and upon the detachment of Lieutenant-Commander Brownson from duty on the Survey, was placed under command of Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey.

*Magnetic observations at Providence, R. I., and on Coaster's Harbor Island, Narrangansett Bay.*—In order to determine the changes that have taken place in the magnetic elements at Providence, R. I., since 1855, when a magnetic station was occupied in the grounds of the University, Sub-assistant J. B. Baylor was directed, in May, 1885, to observe for magnetic declination, dip, and intensity at, or as near as practicable to, the station of Assistant Schott. A new college building having been erected close to this station, a point was selected by Mr. Baylor in a large open space about 225 feet to the east of the former station, and near the college base-ball grounds.

A meridian for reference was obtained by observations on the sun, and the magnetic elements determined on three different days. For horizontal intensity observations were made with the magnetometer, and by the Lloyd method.

Similar observations were made at a new magnetic station located on the highest point of Coaster's Harbor Island, near Newport, the immediate object being to determine a magnetic variation for the new chart of Newport Harbor.

Mr. Baylor has transmitted his records and computations to the office. Duty assigned to him in the earlier part of the season is referred to under the heading of Section II.

*Hydrographic examinations in the approaches to Newport, R. I.*—Upon being detached in September, 1884, from the command of the schooner Drift, Ensign A. F. Fechteler, U. S. N., Assistant Coast and Geodetic Survey, was directed to transfer his party to the schooner Ready, and taking command of that vessel, to proceed with her to Newport, R. I., and make an examination of the rock or ledge in the approaches to that harbor, reported by Capt. J. N. Miller, U. S. N., commanding the steamer Tennessee.

After due search, Ensign Fechteler found the ledge, and it has since been buoyed. It is described in a Notice to Mariners, issued November 1, by this office, as a ledge about one-eighth of a mile in diameter, with a least depth of nineteen and one-half feet over it. The shoalest water was situated on the following bearings:

Seal Rock, N. ¾ E., one-half mile.

Beaver-Tail light-house, NW. by W. ⅜ W., two and one-half miles.

Brenton's Reef light-vessel, W. ¼ S., one and three-eighths miles.

Coggeshall's Ledge, ENE. ½ E., one and three-fourths miles.

In entering Narragansett Bay from the eastward, to avoid this ledge, keep Beaver-Tail light on a bearing to the northward of NW. by W. until Seal Rock bears NNE. ½ E.

Ensign Fechteler had the aid of Ensigns F. W. Kellogg and F. R. Brainard, U. S. N.

In connection with the resurvey of Long Island Sound, and off Cape Henry, Va., other examinations were made by Ensign Fechteler, which are referred to under the headings of Sections II and III.

*Tidal observations at Providence, R. I.*—Records for three successive years have recently been transmitted to this office by Samuel M. Gray, esq., city engineer of Providence, R. I., from the self-registering tide-gauge loaned to the city in 1872. Records for two more years have been promised. Some interruptions have occurred since 1882, but it is hoped hereafter to have these records continuous. Those already received have furnished good results.

## SECTION II.

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

*Topographical resurvey of the northeastern coast of Long Island in the vicinity of Gardiner's Bay, Shelter Island, and Greenport; also, of the north shore of the sound from Darien, Conn., westward.*—In continuation of the resurvey of Long Island Sound, Assistant Charles Hosmer was at work at the beginning of the fiscal year upon the topographical survey of the vicinity of Greenport and Southold, L. I. He had received his instructions towards the end of May, 1884, and had begun the filling in of topographical details west of Greenport early in June. The survey having been completed to include Great Hog Neck by the 20th of September, Mr. Hosmer transferred his party at that date to the schooner Drift to continue the shore-line survey of Gardiner's Bay and Shelter Island Sound.

Field operations were closed on the 5th of November, the advance of the season making it impracticable to continue the work to advantage.

Subassistant W. I. Vinal was attached to the party during the season, and rendered valuable assistance.

The statistics are:

| | |
|---|---|
| Miles of shore-line surveyed | 88 |
| Miles of roads | 61 |
| Area surveyed in square miles | 22 |

During the winter Mr. Hosmer was engaged in office work, and at the opening of the season in 1885 was instructed to organize his party for the continuation of the topographical survey of the northern shore of Long Island Sound, between Darien, Conn., and New Rochelle, N. Y. He has furnished a sketch showing progress to the close of the fiscal year, and given statistics as follows to that date:

| | |
|---|---|
| Miles of shore-line surveyed | 39 |
| Miles of roads | 25 |
| Area surveyed in square miles | 5 |

*Continuation of the topographical resurvey of the north shore of Long Island to the west of Greenport.*—Instructions assigning to Subassistant W. I. Vinal the continuation of the shore-line topography of the south shore of Long Island Sound from the limits of Assistant Hosmer's work of the previous season were issued about the middle of May, and after some delay on account of illness, Mr. Vinal left for the field May 26.

He began the work just west of Goldsmith's Inlet, near the village of Peconic, on the 1st of June, confining himself to a narrow belt of shore-line topography, and to the erection of signals for the use of the hydrographic parties. The topographical features delineated were principally high banks of clay and gravel deeply eroded, detached bowlders inside and outside of the shore-line, many half-tide and low-water rocks, salt-marsh, scrub thickets, and patches of woodland.

Mr. Vinal's survey was making good progress at the close of the fiscal year. Up to that date the statistics are, scale 1-10000:

| | |
|---|---|
| Miles of shore-line surveyed | 13 |
| Miles of roads | 9 |
| Miles of creeks and ponds | 2 |
| Area surveyed in square miles | 3 |

Additional statements of progress will appear in the next annual report.

*Hydrographic examinations off Terry Point and Rocky and Horton's Points, Long Island.*—In order to fill certain gaps in hydrographic work off the north shore of Long Island, Ensign A. F. Fechteler, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner Ready, was directed, in September, 1884, to obtain the necessary soundings off Terry Point and Rocky and Horton's Points. Upon the completion of this work, he made a hydrographic survey of Southwest Ledge near Duck Island, to the west of Menunketesuck Point, finding no depth less than five fathoms.

Ensign Fechteler's examination of a ledge in the approaches to Newport Harbor has been referred to under the heading of Section I. Duty subsequently assigned to him off Cape Henry, Virginia, will be mentioned under Section III.

Ensigns F. W. Kellogg and F. R. Brainard, U. S. N., were attached to the Ready, and aided in the work.

*Topographical resurveys at the mouth of the Connecticut River, and near Milford and Stratford, on the north shore of Long Island Sound; also, from Lloyd's Neck eastward on the south shore.*—As stated in the last annual report, at the beginning of the fiscal year, Assistant W. C. Hodgkins was in the field in charge of a topographical party at Saybrook, Conn., in continuation of the resurvey of the north shore of Long Island Sound.

Work was continued in the vicinity of the villages of Lyme and Saybrook, at the mouth of the Connecticut River, until the end of August. It consisted mainly of interior topography and village details, in extension of the work of the previous season, where most of the shore-line had been surveyed. There was, however, some shore-line work in various coves and creeks which had not been reached before.

The character of the topography varied considerably. Over a great part of the area surveyed, the ground is low and rolling, and there are considerable areas of salt marsh which are cut up by numerous branching creeks. Between two or three miles back from the Sound, the ground rises rather suddenly to a range of rocky hills from one hundred to two hundred feet high. The villages of Lyme and Saybrook are situated on the low and nearly level ground south of these hills. They are quiet country places, each village consisting mainly of a single long street, very broad, and bordered on each side by lofty elms. Both villages were included in the area surveyed, together with the surrounding cultivated land, and enough of the hill border to show the character of the section.

On the 1st of September, the work near the mouth of the Connecticut having been completed, the party was transferred to Milford, Conn., to take up the resurvey of the shore-line between the work of Assistant R. M. Bache, west of New Haven, and that of Assistant E. Hergesheimer at Bridgeport. Between New Haven and Bridgeport the character of the country is much the same as that farther east. The hills, however, approach more closely to the shore, and more rock is found, forming numerous ledges offshore in the vicinity of Merwin's Point.

For the purposes of the plane-table survey, a small triangulation was laid out, four stations were occupied, and a number of spires and other prominent objects determined. At the time of closing field operations, November 15, some work had been done on the Housatonic River near Stratford and in Milford Harbor; some topography near the shore completed in details, and the entire extent of outer shore-line finished on two topographical sheets, to a junction with the topography near Bridgeport.

During the winter Mr. Hodgkins was engaged in inking his field sheets, and at the opening of the season in 1885 was instructed to resume field work. His party was organized May 18. In the vicinity of Stratford the survey of the shore line was carried up the Housatonic River as far as the railroad bridge, and included the marsh formation opposite Stratford known as Nell's Island. The low-water outline was also surveyed, wherever it had been left incomplete last season, the high winds of the preceding autumn having made it impracticable to take a boat on the extensive shoals off the mouth of the Housatonic or among the rocks off Stratford Point.

At intervals, as the state of the tide favored, the survey was extended inland so as to include the whole of the island known as Stratford Point, and the creek or thoroughfare, locally known as the Gut, which separates the point from the mainland was surveyed throughout, to its junction with Bridgeport Harbor. This channel, which is nearly dry in many places at low water, forms a safe passage at high water for small craft between Bridgeport and Stratford.

Work in the vicinity of Bridgeport was closed June 11, and next day the party was transferred to Huntington, Long Island, to take up the resurvey of Lloyd's Neck and the shore to the eastward. At the close of the fiscal year, the necessary preliminary work of putting up signals and determining new points was well advanced.

Mr. J. W. G. Atkins was attached to the party as acting aid during the season, and rendered diligent service.

The statistics of work of the year in the several localities are as follows, the scale being 1-10000:

| | |
|---|---|
| Connecticut River: | |
| Miles of shore-line surveyed | 30 |
| Miles of railroads and other roads | 24 |
| Miles of creeks | 22 |
| Area surveyed in square miles | 8 |
| Vicinity of Milford and Stratford, Conn.: | |
| Miles of shore-line surveyed | 70 |
| Miles of roads | 22 |
| Miles of creeks, including low-water and marsh outlines | 50 |
| Huntington, Long Island: | |
| Miles of shore-line surveyed | 5 |
| Miles of roads | 2 |

*Continuation of the topographical resurvey of the north shore of Long Island Sound in the vicinity of Madison, Guilford, and Branford, Conn.*—At the beginning of the fiscal year, the party of Assistant W. H. Dennis had been in the field for nearly a month, engaged in filling in the details of shore-line topography in the towns of Madison and Guilford on the north coast of Long Island Sound.

This survey connects with Mr. Dennis's work of the previous season in the town of Clinton. A small supplementary plane-table sheet had been laid out to cover Falkner's Island.

By the 17th of November, when field operations were closed for the season, the topography of the Connecticut shore in the towns of Madison and Guilford, and that of Falkner's Island, was finished, and a beginning had been made on the plane-table sheet of the town of Branford, carrying the survey westward towards New Haven.

The statistics of work accomplished are as follows:

| | |
|---|---|
| Miles of shore-line surveyed | 39 |
| Miles of roads surveyed | 58 |
| Miles of creeks surveyed | 30 |
| Area surveyed in square miles | 17 |

Subassistant C. H. Oan Orden was assigned to duty in the party early in August, and served with great acceptance to the close of the season. Mr. J. W. Dudley rendered service as acting aid

In May, 1885, Mr. Dennis, who had been on office work during the winter, was instructed to reorganize his party for the continuation of the survey in the town of Branford. His report of the progress of this survey to the close of the fiscal year has been received. Many ledges and rocks were included in the work which could only be delineated at low water. The statistics to June 30 are:

| | |
|---|---|
| Miles of shore-line surveyed | 23 |
| Miles of roads, creeks, and marsh lines | 47 |
| Area surveyed in square miles | 6 |

Lieut. G. Lange, of the Norwegian general staff, was assigned to the party as aid on the 1st of June, and proved a very valuable assistant.

*Inshore hydrographic survey of the northern coast of Long Island Sound from Hammonassett Point to Welch's Point.*—In continuation of the hydrographic resurvey of Long Island Sound, Lieut. W. G. Cutler, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner Palinurus, was instructed, at the outset of the fiscal year, to organize his party on board of that vessel and take up the hydrography of the north shore of the Sound between Hammonassett Point and Welch's or Cedar Point, on the eastern side of Milford Harbor.

This survey was begun July 18, 1884, and was completed November 14. Its results are comprised in four hydrographic sheets on a scale of 1-10000, with limits as follows: Sheet No. 1, from Hammonassett Point to Sachem's Head; Sheet No. 2, from Sachem's Head to Branford Beacon; No. 3, from Branford Beacon to Southwest Ledge Light, and No. 4, from Southwest Ledge Light to Welch's Point.

The soundings upon sheets 1 and 2 were reduced to mean low water of a tide-gauge established on Falkner's Island; those on sheets 3 and 4 to mean low water of the Southwest Ledge Lighthouse tide-gauge.

Lieutenant Cutler has submitted a report of his season's work which bears witness to most careful and exhaustive study of the hydrographic characteristics of the localities included in his survey. Close examinations were made of all harbors or anchorages, sailing directions for entering given, and all dangers minutely described. His suggestions and notes will be of great value in future editions of the local Coast Pilot. Certain dangers developed by his survey, and not heretofore shown on the charts, were brought to public attention by the publication of the following Notice to Marines, bearing date of November 1, 1884:

*Six-Mile Reef.*—This is an extensive patch of shoal ground lying near the middle of the Sound, about six miles from Clinton, Conn. The general depth of water covering the reef is from five to seven fathoms except on a small ledge situated near the western part of the reef. This ledge is about one-fourth of a mile in diameter and has three and one-fourth fathoms on its shoalest spot, which is located on the following bearings:

Falkner's Island Light-House, WNW., seven and one-eighth miles.

Southern extremity of Hammonassett Point, N. by W. ⅝ W., four and one-fourth miles.

Cornfield Point Light-Vessel, ENE. ½ E. five and one-half miles.

Horton's Point Light-House, S. by E. ¼ E., six and one-half miles.

Vessels bound through the Sound from the Race, if following the directions for the main channel passing to the northward of Stratford Shoal Light, will pass about one-fourth of a mile to the southward of this rock.

*Northwest Reef.*—This is of very small extent, has a depth of six and one-half feet over it, with surrounding depths of five and six fathoms, and is located on the following bearings:

Branford's Reef Beacon, WSW., one and one-half miles.

Falkner's Island Light-House, ESE., five and three-fourths miles.

Lone Tree on Outer Thimble, ENE., seven-eighths of a mile.

All bearings in this Notice are magnetic, all distances in nautical miles, and all depths at mean low water.

Lieutenant Cutler makes special mention of the fact that Branford Reef extends more to the northward than to the southward of the Beacon, and should not be approached from the northward nearer than about one-fifth of a mile. Branford Harbor he deems a very desirable anchorage for vessels drawing ten feet, desiring protection from the eastward, northward, or westward. It is not obstructed by ledges or sunken rocks and has no dangers which are not in sight or buoyed.

With regard to the approaches to New Haven Harbor, he observes that a breakwater two thousand one hundred and sixty feet in length now extends from Southwest Ledge Light in the direction of Quixe's Ledge; hence the Light Lists and Buoy Lists, which state that Southwest Ledge Light may be approached close to on all sides, need some modification.

Ensigns F. H. Sherman and J. S. Watters, U. S. N., were attached to the Palinurus.

The statistics of the work are:

| | |
|---|---|
| Miles run in sounding | 515 |
| Angles measured | 6,677 |
| Number of soundings | 40,377 |

During the winter the Palinurus was laid up at the navy-yard, New York. As early as practicable after the appropriation for the resurvey of New York Harbor became available, Lieutenant Cutler was assigned to duty on that work, reference to which will be made later in this report.

*Tidal observations with an automatic tide-gauge at the Light-House on the New Haven Breakwater.*—Mention was made in the last annual report of the completion of somewhat more than a year's record of the tides on a self-registering tide-gauge which had been established at Fort Trumbull, New London, Conn. At the beginning of the fiscal year this gauge was transferred to the Light-House on the New Haven Breakwater, and a tidal record was begun July 31, 1884, which was continued until December 2. This record was begun again May 12, 1885, and will be kept up during the season. It is under the general supervision of the chiefs of hydrographic parties in Long Island Sound, and will furnish a plane of final reference for the soundings as the hydrography reaches New Haven Harbor and advances westward.

*Continuation of the topographic resurvey of the north shore of Long Island Sound westward from Frost (or Farms) Point, and including the Norwalk Islands; also topographical resurvey of the shores of East River, New York.*—Towards the close of July, 1884, Assistant E. Hergesheimer, under instructions to resume the topographical resurvey of the north shore of Long Island Sound and carry it westward from the limits of his previous season's work, began field operations, and by the 16th of October had completed the topography of the north shore to South Norwalk and as far inland as the New York, New Haven, and Hartford Railroad. The survey included also the Norwalk Islands.

The statistics of this survey are:

| | |
|---|---|
| Miles of shore line surveyed, including shore line of rivers, creeks, and ponds | 90 |
| Miles of roads | 44 |
| Area surveyed in square miles | 6 |

During the winter Mr. Hergesheimer inked his plane-table sheet with more than usual care as a sample of topographical delineation on a scale of 1–10000, and deposited it in the office.

For the purpose of noting topographical changes and additions on the water front of the inner harbor of New York and the East River, Mr. Hergesheimer left Washington under instructions on the 27th of October, and upon reaching New York made an examination of the water front of East River and the inner harbor, in order to decide in what localities the changes were so marked as to require resurveys, and the extent to which the local municipal surveys could be made available. After completing this examination, November 7, Mr. Hergesheimer returned to the office and submitted a detailed report of it with estimates of cost of surveys.

At the opening of the season in 1885 instructions were issued to Mr. Hergesheimer, acting under which he left Washington, April 27, and organized his party for a resurvey of the shore topography of the East River from Red Hook to Throg's Neck. In executing this work he was authorized to make use of such details of previous work by the Coast and Geodetic Survey, by the Department of Surveys of Brooklyn, and by the Department of Docks of New York City as upon verification in the field he might find to be trustworthy.

As the work progressed, tracings of shore line were supplied to the hydrographic parties. Mr. Hergesheimer had completed one table sheet and transmitted it to the office, and had begun a second soon after the close of the fiscal year. A fuller account of his work is necessarily reserved for the next annual report.

Mr. J. H. Gray was attached to the party as aid during both field seasons, and rendered acceptable service.

*Triangulation in the western part of Long Island Sound extended from Lloyd's Neck towards New Rochelle.*—At the beginning of the fiscal year, the party of Assistant Gershom Bradford was at Oyster Bay, Long Island, engaged in the preliminary work of reconnaissance and building signals for the extension of the triangulation of Long Island Sound westward from Captain's Island on the north shore of the Sound and Lloyd's Neck on the south shore. With some interruption, owing to delay in the passage of the appropriation, the work was continued until August 28, when it became desirable to assign Mr. Bradford to another field of duty. As already mentioned under the heading of Section I, he reported to Assistant Henry L. Whiting early in September to carry on under his general direction a triangulation in aid of the topographical survey of the State of Massachusetts.

After the close of field-work, December 4, in that State, Mr. Bradford was occupied during the winter in completing his records and computations, and towards the end of May, 1885, was directed to proceed to the western part of Long Island Sound, to furnish points for the topographical parties at work in that locality, and to continue his work of the season of 1884. Working eastward from New Rochelle, N. Y., on the north shore, he carried the triangulation to Captain's Island, and then crossed the Sound to Sea Cliff in Hempstead Harbor and closed the gap in the survey between the line Captain's Island–Oak Neck, the eastern limit, and the line Prospect Point–Whortleberry Island, the western limit, including Hempstead Bay.

Following are the statistics of field-work to the close of the fiscal year:

| | |
|---|---|
| Number of stations determined | 27 |
| Number of horizontal angles observed | 113 |
| Number of measurements (direct and reverse) | 1,404 |

At the date of which this report closes the triangulation is still in progress.

*Topographical resurvey of the north shore of Long Island Sound continued from Darien, Conn., towards New Rochelle, N. Y.*—Mention has already been made of the progress of the topographical resurvey of the north shore of Long Island Sound from Darien, Conn., westward under the first caption in this section. Assistant Hosmer, in charge of the party, has submitted a report with statistics, showing satisfactory progress up to the close of the fiscal year. A more detailed statement will be presented in the next annual report.

*Topographical resurvey of the shores of the East River, New York.*—At the date at which this report closes, a topographical resurvey of the shores of the East River, New York, is making excellent progress under the direction of Assistant E. Hergesheimer. Mention in some detail of this work has been made under a previous heading in this section referring to surveys westward from Farms (or Frost's) Point. In the next annual report a full account of it will appear.

*Hydrographic resurvey of the East River, New York.*—Early in May, 1885, Lieut. J. M. Hawley, U. S. N., Assistant Coast and Geodetic Survey, was directed to organize a party on board of the schooner Eagre for the purpose of making a hydrographic resurvey of the East River, New York.

Having anchored the Eagre on the shoal to the southward of Governor's Island, and established a self-registering tide-gauge on the northwest corner of that island, near Castle William, Lieutenant Hawley by the 30th of June had completed the hydrography of the East River to Brooklyn Bridge, with that of a portion of the upper bay.

He had the aid of a steam launch from the Navy-Yard, and acknowledges the many courtesies extended to the party by the officers stationed at Governor's Island. He mentions also the great assistance rendered in the work by the shore line and positions of stations furnished by Assistant Edwin Hergesheimer, in charge of the topographical resurvey of the shores of the East River.

As may be supposed, much difficulty was experienced in that crowded port in running lines of soundings, on account of passing vessels. The launch carried a black ball on the flag-pole, and notices were published in the New York papers calling attention to the significance of this ball, but with the exception of the ferry-boats, few vessels gave the launch the right of way.

In addition to the regular lines of soundings, many lines were run, very close together, across Dimond Reef, upon which the least water found was twenty-one feet.

The statistics of the survey, upon a scale of 1-5000, to the close of the fiscal year, are as follows:

| | |
|---|---|
| Miles run in sounding | 156 |
| Angles measured | 2,736 |
| Number of soundings | 11,700 |

Ensigns F. H. Sherman, A. W. Dodd, and R. O. Bitler, U. S. N., were attached to the Eagre, and aided Lieutenant Hawley in the work. As it is still in progress, further mention of it is reserved for the next annual report.

*Determination of points for the resurvey of New York Lower Bay.*—Soon after the middle of April, 1885, instructions were issued to Assistant E. F. Dickins to proceed to New York and make the triangulation needed for the resurvey of New York Bay and Harbor. He was directed to concern himself first with the points required for the resurvey of the lower bay, and especially those on the south side of Coney Island and Rockaway Beach. He was to examine the condition of the old points with a view of recovering as many as practicable, re-establishing those that had been lost, and supplementing additional points where necessary.

In this work he was occupied till June 26, when he was detached and received orders to prepare for duty upon the Pacific coast.

Mr. Dickins reports the following statistics:

| | |
|---|---|
| Stations recovered | 8 |
| Signals erected | 12 |
| Stations occupied | 15 |
| Objects observed | 93 |

*Hydrographic resurvey of the entrance to New York Bay.*—In the spring of 1885, instructions were issued to Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, to fit the steamer Endeavor for service, and to proceed to make a hydrographic resurvey of New York lower bay and entrance.

The vessel arrived at New York from Norfolk April 28, and the party having been organized, preparations for the work by building signals, &c., were begun. Soundings were commenced June 2. A full report of operations is necessarily deferred to the next annual report. Up to June 30, the close of the fiscal year, the statistics were:

| | |
|---|---|
| Miles run in sounding | 320 |
| Angles measured | 5,247 |
| Number of soundings | 16,411 |

The following-named officers were attached to the party on board of the Endeavor: Ensigns C. S. Ripley, E. F. Leiper, F. R. Brainard, and G. R. French, U. S. N.

Other duty executed by Lieutenant Hanus is referred to under the headings of Section V and VI.

*Topographic resurvey of the shore lines of Coney Island and Rockaway Beach, New York Lower Bay.*—That portion of the topographic resurvey of New York Bay and Harbor which included the shore lines of Coney Island and Rockaway Beach was committed to the charge of Assistant Joseph Hergesheimer. He took the field June 18, 1885, and has submitted a report showing satisfactory progress during the limited time elapsing between that date and the close of the fiscal year. The next annual report will give a fuller account of this work.

Mr. Hergesheimer's field-work during the previous winter on the Gulf coast is reported under the heading of Section VI.

*Topographic resurvey of the shores of the North River, New York.*—Early in June, 1885, Assistant D. B. Wainwright was directed to proceed to New York and take up the topographical survey of the shores of North River, from Red Hook and Caven's Point to Fifty-ninth street and the opposite shore. The immediate object of this work was to supply positions and shore-line needed by the hydrographic parties. Mr. Wainwright was instructed also to confer with Assistant E. Hergesheimer in regard to obtaining and using data from the municipal authorities of New York and of the towns on the New Jersey shore, availing himself of all necessary shore-line within their control, but always determining the position of salient points by the plane-table.

In pursuance of these instructions, and to meet the wants of the hydrographic survey, he began by determining all prominent buildings and objects suitable for signals from the Battery to Fourteenth street on the New York side, and from Communipaw to Castle Stevens on the New Jersey side. Points on the upper topographic sheet were then determined on the New York shore and opposite from Fourteenth street to Eighty-third street. Tracings showing position of signals determined were furnished to the hydrographic parties.

Mr. Wainwright then began the work of delineating the shore-line on the New York side, and by the close of the fiscal year had completed the field survey from Fourteenth street to Sixty-fifth street. He found it advisable to extend the work somewhat beyond the assigned limits in order to include the new and very large docks of the New York Central Railway, which are also the last of any importance on the New York side.

Preparations were then made to take up the shore-line survey on the New York side from Castle Point to Weehawken Ferry. Further mention of Mr. Wainwright's progress is necessarily deferred to the next annual report. His services in the earlier part of the fiscal year are referred to under the heading of Section III.

*Hydrographic resurvey of the North River, New York.*—That portion of the hydrographic resurvey of New York Bay and Harbor included in the North River and its approaches, was assigned in May, 1885, to Lieut. William G. Cutler, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner Palinurus. Lieutenant Cutler began soundings May 23, and between that date and June 30 had finished the resurvey of the North River, with the exception of the wharf-lines from Castle Garden to Weehawken Ferry. The hydrographic projections furnished to Lieutenant Cutler for his work were upon a scale of 1–5000. A more detailed account of this survey will appear in the next annual report.

Ensigns E. E. Wright and A. G. Rogers, U. S. N., were attached to the Palinurus.

Mention has been made under a previous heading in this section of the hydrography executed by Lieutenant Cutler on the north shore of Long Island Sound, between Hammonassett Point and Welch's or Cedar Point.

*Development of plans for the study of the physical hydrography of New York Bay and Harbor.—Need of special examinations to ascertain the physical history of the changes in Monomoy Shoals.*—As soon as practicable after the appropriation for the resurvey of New York Bay and Harbor became available, Assistant Henry Mitchell was directed to reopen the study of the physics of the harbor, and supervise the further collection of data for the purpose of ascertaining the laws of action of its tides and currents.

Assistant H. L. Marindin was at the same time instructed to organize a field party with such subdivisions as Mr. Mitchell might advise, and authority was given to procure by transfer from the service of the Mississippi River Commission two trained experts in river gauging. To Mr. Marindin's party Assistant Marcus Baker was assigned, his instructions, dated May 28, 1885, directing him to proceed to Boston and report to Mr. Mitchell for general conference and consultation in conjunction with Mr. Marindin.

At the date at which this report closes, two parties had been organized for the hydrological survey, one in the schooner Drift, under the command of Lieut. F. S. Carter, U. S. N., Assistant Coast and Geodetic Survey, and the other in the schooner Scoresby, Assistant Marcus Baker commanding. Their work was to ascertain what are the functions of the different bays and rivers emptying into New York Harbor in maintaining the depths over Sandy Hook Bar.

Mr. Mitchell has indicated the following physical questions as among the most important, perhaps, that have remained unsolved with regard to the projects of encroachment in different parts of the harbor:

(1) In what relative proportions do the two entrances of the harbor supply its tidal volume?

(2) In what relative proportions do the two entrances to the harbor discharge the river waters, and how do these proportions differ with floods and low stages of the Hudson?

(3) To what depth, if limited, does the influence of the river water extend, and how does this depth vary with amount of river discharge?

(4) To what extent is the Hudson River a tidal reservoir as affecting New York Harbor; *i. e.*, at what distance above New York would an exclusion of the tide reduce the flow through the harbor below, at the period of least fresh-water discharge?

(5) What is the physical value of Newark Bay as a tidal reservoir tributary to New York Harbor?

With regard to this important harbor, Mr. Mitchell remarks that the former physical survey cannot be repeated to advantage except by an expenditure of time and money that will make it practicable to occupy a number of points simultaneously, so that the work will faithfully reflect all that goes on in the great channels at the same instant of time.

*Monomoy Shoals.*—Very serious apprehensions are felt relative to the increase of obstructions at the eastern entrance to Nantucket Sound, and great difficulty has been experienced in keeping the chart correct, especially as regards the sailing lines. The increase of the shoals and their movements have been pretty well connected with the rapid degradation of the shores of Cape Cod, at and above Chatham, so that it is almost certain that some movements of the sea, not yet properly gauged, must account for both the destructive and constructive phenomena observed.

Although glacial cliffs along the coast are everywhere giving way before the dash of the sea, the destruction is not rapid, except where there runs in some ocean current (tidal or otherwise) to carry off the débris as fast as it falls into the sea. One observes from a comparison of ancient and modern charts, and even from repeated surveys in our own time, that the submerged contours near the elbow of Cape Cod fall back somewhat as the coast recedes, and the Monomoy Shoals increase as they move to the southwestward.

This movement of the shoals has reduced the width of the channel known as "Butler's Hole" to one-half its former width, and has shown across the great south channel "lumps" of deposit, which render the deep track tortuous and dangerous.

In his annual report, Mr. Mitchell recommends that the physical history of these changes be ascertained, not only by comparing ancient and modern maps and surveys, but by observing the waves and currents till the dynamic scheme is plainly brought out. It may be that no remedy for the deterioration is possible, but until a diagnosis of the case has been made, no such verdict can be declared against the interest of over twenty-five thousand vessels that annually pass this way.

*Mississippi River Commission.*—The survey is represented by Mr. Mitchell upon the Mississippi River Commission. Much of his time is thus employed, but not to the exclusion of other duties. His relation to the work of the Commission he makes a theme in his annual report for the sake of recording his objection to the proposed high-water closure of the Atchafalaya, on the ground, principally, of its increasing the velocity of the great floods to an extent that would sometimes prevent vessels from towing up to New Orleans from the sea, should the present river banks (and lands adjacent of almost incalculable value) hold against the wear of the main stream.

*Advisory Commissions.*—In his annual report, Mr. Mitchell, referring to advisory commissions in general, says: "They are a body of experts who study the physical data and the generic wants of navigation. In recommending the harbor lines, those beyond which no one shall build and to which building in a certain order shall be prosecuted, the advisory board does not recognize individual interests or enterprises, although it frequently happens that the adjustment of rival interests turns upon its decisions. It is usually the function of the local commission to have hearings of parties in interest, and settle disputes, but an appeal is made to the advisory commission in all cases where decisions may rest upon physical data. The particular value of the advisory commission appears when two rival interests, both disposed to be fair, but each jealous of the other, find themselves confronted by a physical reason, a reason based upon the natural laws of the tides, currents, or cross-sections. I have so often seen cases settled in this way that I have come to think a physical reason the best reason, because recognized as *higher law*. One may easily see that rival claimants for water space on opposite shores of a river cannot be equally entitled, because the river flow is not the same on the two shores, and encroachment from one shore must disturb it more than from the other. In very many ways such inequalities present themselves, and the party losing discovers that his best interests lie in gracefully and promptly yielding to a reason which the community is ready to adopt."

Special reports have been presented by Mr. Mitchell respecting the necessity of a light-house upon George's Shoal, and upon the changes in extent and location of the shoals in Delaware Bay.

Later, under the heading of this section, is given a résumé of the work of Assistants Mitchell and Marindin with reference to the adjustment and solution of important practical questions affecting the navigation of Delaware Bay and River, and the respective limits of jurisdiction of the States of New Jersey and Delaware over the waters of the river and bay.

*Records of observantions with self-registering tide-gauges at Governor's Island and at Sandy Hook.*—Early in May, 1885, an automatic tide-gauge was established on the wharf at Governor's Island, New York Harbor, to be used in connection with the hydrographic resurvey of the harbor and bay. This gauge will have the supervision of the naval officers in charge of the hydrographic parties in that vicinity. The records from the self-registering gauge which was maintained at the same location on Governor's Island for upwards of sixteen years, ending in 1879, yielded valuable data for the study of the tides of New York entrance.

The automatic tide-gauge at Sandy Hook, New Jersey, which has been kept in operation with comparatively few interruptions for several years, was in charge of Mr. F. W. Shepheard during July and August, 1884. A stoppage of several months then followed, owing partly to the necessity of repairing the gauge, and of training a new observer, Mr. Shepheard having resigned. Towards the end of March Mr. J. W. Corbett was placed in charge, and records have been received since the close of that month.

*Topographical resurvey of Sandy Hook, New Jersey.*—Changes in the shore-line of Sandy Hook and of the hydrography in its vicinity, as affecting the main ship channel abreast of the Hook, have called for much study, based upon careful resurveys, to ascertain the laws governing these changes, and to determine their extent and influence. In connection with the resurvey of New York Bay and Harbor, a topographical resurvey of the Hook was deemed essential, and early in June, 1885, this work was assigned to Mr. E. L. Taney, an aid in the Survey of tried ability as a topographer. Mr. Taney organized his party and arrived at the Hook June 16, and at the date at which this report closes was actively at work. Further mention of his progress will be made in the next annual report.

*Extension of reconnaissance and triangulation in the southern part of the State of New Jersey.*—As stated in my last annual report, geodetic operations in the southern part of the State of New Jersey were resumed by Prof. E. A. Bowser, acting assistant, at as early a date as practicable in the spring of 1884. At the beginning of the fiscal year Professor Bowser had selected a sufficient number of points to the west and southwest of Williamstown, Gloucester County, to close the horizon around that station. The country being mostly flat, and in many places heavily wooded, signals ranging in height from forty to upwards of one hundred feet had to be erected to make the reconnaissance successful.

On July 7 the occupation of stations of the triangulation was begun, additional reconnaissance having been postponed till later in the season. Station Applepie Hill, about five miles west of the town of Shamong, Burlington County, was first occupied. Five primary points were observed upon from this station, the point farthest to the east being Ridgeway, distant from the Atlantic coast a little over seven miles, and the most western point, Berlin, being within twelve miles of the Delaware River.

Upon the completion of observations at Applepie Hill, August 26, the old monument which had marked the station was placed five and a half feet below the surface of the ground, and a granite post of the usual dimensions for a surface mark was set in hydraulic cement, its top, upon which the center of the station had been marked, being within six inches of the surface.

Berlin Station, near the town of that name, in Camden County, was next occupied, and on the

26th of September, all observations at this station having been finished, the point was marked in the same way as the first station.

The triangulation closed November 5 with the occupation of station Mount Holly, Burlington County, and on the next day Professor Bowser resumed the reconnaissance, and by the end of the season had carried it southward to the line Kellogg–Russia, the latter station being about seven miles northwest of Tuckahoe, on the river of the same name, which flows into Great Egg Harbor, and the former three and a half miles northeast of Millville, Cumberland County.

Following are the statistics of the work:

| | |
|---|---|
| Number of angles measured between primary stations | 18 |
| Number of angles measured between secondary and tertiary stations | 20 |

At the opening of the season in 1885 Professor Bowser was instructed to take the field in continuation of the reconnaissance and triangulation of the State.

*Extension of reconnaissance and triangulation in the eastern portion of the State of Pennsylvania.*—Up to the beginning of 1884, the geodetic operations carried on for some years preceding in the eastern and southeastern portions of the State of Pennsylvania had determined accurately in geographical position thirteen stations of the triangulation resting on the fixed primary lines Meeting House–Principio and Newtown–Mount Rose.

A large number of subsidiary points had also been determined, including church spires and prominent buildings. Through the line Newtown–Mount Rose a connection had been obtained with the triangulation of the State of New Jersey.

Early in July, 1884, Prof. Mansfield Merriman, acting assistant, was instructed to organize a party for continuing the triangulation and reconnaissance, and began the occupation of station Swatara Gap, about eleven miles northwest of Lebanon, Lebanon County.

Heliotropers were posted at Womelsdorf, Round Top, and Dauphin; a tower with signal was erected at White Horse, and a signal placed at Governor Dick. But few observations could be taken in July, the weather being foggy and rainy. The line from Swatara Gap to Round Top, upwards of thirty-two miles long, led across the valley of the Susquehanna, and over the Steelton Iron Works, and no measurements of its direction could be obtained until August, and then at but rare intervals. On account of these difficulties, the observations at Swatara Gap could not be completed till August 30, when the triangulation was closed, and the limited time remaining devoted to reconnaissance.

Professor Merriman's first efforts were directed toward a revision of the location of stations west and southwest of the meridian of 77°, so as to obtain a favorable connection with the Maryland triangulation through the stations Fairview and Maryland Heights. This was accomplished by selecting a very prominent point, Mount Misery, in Maryland, about a mile south of the State line, and 2,300 feet elevation above tide. In Pennsylvania this station connects with Piney Mount and Pulpit Rock.

During part of August and in October, Professor Merriman began a reconnaissance along the meridian of 76° in the vicinity of Mauch Chunk, Carbon County, for the purpose of connecting the triangulation of Pennsylvania with that of New York. The reconnaissance was carried to within seven miles of Wilkes Barre, Luzerne County. Field-work was closed in October.

In order to expedite this reconnaissance and allow more time to Professor Merriman for the triangulation during the two or three months of each year available for his field operations, Assistant O. H. Tittmann was directed in June, 1885, to continue it northward from points already established, so as to include in the trigonometric network the coal fields of Luzerne County. He was instructed also to determine whether it was practicable, in the locality just mentioned, to develop the reconnaissance for the primary scheme incidentally to the work of fixing trigonometric points with sufficient accuracy for the collocation of local topographical State surveys on a general map.

Professor Merriman was at the same time directed to resume work upon the triangulation of Pennsylvania as early as practicable, and his co-operation with Assistant Tittmann was provided for.

A statement of the results reached by the labors of these gentlemen is necessarily deferred to the next annual report.

*Reconnaissance for triangulation in the western half of the State of Pennsylvania.*—Towards the close of the fiscal year, the appointment of Prof. L. H. Barnard as acting assistant was renewed and he was charged with the conduct and execution of the work of triangulation in the western half of the State of Pennsylvania. He was directed to begin by making a reconnaissance of precision connecting two points on the Tussay Mountain, or on Broad Top, with points already determined in the vicinity of Lancaster and Harrisburg.

Professor Barnard visited Washington, and after having informed himself thoroughly of the conditions and limitations of the work in conference with the Superintendent, conferred also with Dr. Charles A. Ashburner, geologist in charge of the anthracite coal fields of the State, in reference to the operations desired by the State Geological Survey. An account of his progress will find a place in the next annual report.

*Special triangulation for the city of Philadelphia.*—A request having been made by Mr. Samuel L. Smedley, Chief Engineer and Surveyor, in behalf of the authorities of the city of Philadelphia, for the trigonometric determination of a number of points in and around the city, Assistant S. C. McCorkle was directed to execute this work after conference with Mr. Smedley, and began the preliminary reconnaissance towards the end of November. Other duties interfered to prevent the completion of the reconnaissance by Mr. McCorkle, and early in January, 1885, Subassistant C. H. Van Orden was directed to report to him. By the end of that month Mr. Van Orden had finished the reconnaissance, erected five signals, and occupied four stations. Exposure to wind and cold at a station on the roof of Girard College January 31 brought on an attack of illness, which for a time completely prostrated Mr. Van Orden and compelled his relief from field duty. Some delay was thus occasioned, but towards the end of February Assistant C. H. Sinclair was ordered to take up the work under Mr. McCorkle's direction, and by the end of March he finished it.

During its progress the tower of the new City Hall, which had then reached an elevation of one hundred and ninety-two feet, was occupied as a station.

The statistics of the work are:

| | |
|---|---|
| Number of points determined | 19 |
| Number of angles measured | 151 |
| Number of observations | 1,680 |

It remained to connect this local triangulation with the primary series, and for this duty Mr. Van Orden, whose health had been restored, was directed in April, 1885, to report to Mr. McCorkle. The line Mount Holly–Girard College was at first proposed as the desired base, but finding it practicable only by expensive opening of lines, the line Pine Hill–Girard College was substituted. This line, in connection with the station at Bellevue Hotel, Red Bank, N. J., presented a satisfactory solution of the problem. The stations at Girard College and Bellevue Hotel were reoccupied for the measurement of additional angles in order to give greater weight to observations previously made. In all fourteen angles were measured and five points determined in positions by three hundred and twenty-four observations. The results of this work and of that before referred to have been communicated to the city Chief Engineer.

In the annual report for 1879 mention was made of an examination of the movement of ice in the Delaware, conducted by Mr. McCorkle along the stretch of river from Bridesburg, above the city, to Fort Mifflin, below it. Similar examinations were made, in pursuance of instructions, by Mr. McCorkle during the winter of 1884–1885, which is said to have been one of the most severe known there for forty years. The ice was found to be unusually heavy, notably below the Horseshoe. The largest accumulations of ice were found at the Narrows, between Gloucester and Greenwich Points, in the bend at the Horseshoe, and below Fort Mifflin.

Mr. McCorkle has submitted a full report of the results of his observations, accompanied by illustrative maps, and the recommendations he makes will be of interest to the United States advisory commission on the improvement of the Delaware River.

*Physical hydrography of Delaware River and Bay.*—The studies of the physical hydrography of Delaware River and Bay, especially those bearing upon the changes in the extent and location of the shoals, have been continued by Assistants Henry Mitchell and H. L. Marindin.

Mr. Mitchell has submitted a report which reflects fairly the aspect of his work, and in which he refers to an important practical conclusion, drawn from his study of the river and bay, and which settled a question of jurisdiction between the States of New Jersey and Delaware, and between these two States and the General Government.

Some extracts from this report are as follows:

"Quite beyond the jurisdiction of the Harbor Commission of Philadelphia or its advisers, we have been making a study of the changes in the extent and location of the shoals. My own part has been inquiries into the general laws of sectional areas, in which I have been assisted, fortunately, by Mr. J. A. Sullivan, upon whom most of the work has fallen. Appendix 8, Report for 1883, established certain laws of depth and surface width, and gave rise to the question: Is the surface width a proper criterion; should it not be the mean chord, or perhaps the chord of mean depth? A computation of mean chord was clearly out of the question, but Mr. Sullivan undertook the computation of the chord of mean depth, and I insert his table, with illustrative diagrams, on which we are not yet prepared to offer conclusions. I want, however, to record one thought about the mean section that may prevent its misleading; it is this: Since for these forty-six miles right hand and left hand turns enter the mean section, it cannot be a characteristic natural section, but must be nodal.

"In the appendix to the report for 1883, referred to above, I took some pains to call attention to very important practical conclusions from a study which might otherwise have appeared speculative. At that time I did not dream that this study would come to have political value, but it appears from the report of Hon. John P. Stockton, Attorney-General for New Jersey, and from the letter of Hon. John H. Paynter, Attorney-General of Delaware, that a question of jurisdiction between these two States, and between these States and the General Government, is likely to be settled to the satisfaction of all parties upon the basis of our solution of a physical problem. And here I must repeat what I said in a former report when commending advisory harbor commissions, that a physical reason is the best reason because the higher law."

A brief statement of the question of jurisdiction referred to by Mr. Mitchell will be in place here. Citizens of the State of New Jersey had claimed and exercised the right of fishing in the river Delaware. This claim had been resisted by the State of Delaware, and the boats and nets of the New Jersey fishermen had been seized by Delaware on the charge of violating the statute laws of that State by fishing within its limits. This had been done notwithstanding the fact that an injunction of the Supreme Court of the United States had been issued forbidding such action by the State of Delaware, the authorities of that State claiming that their statute laws had been violated because the fishing was done within the limits of Delaware in Delaware Bay, and not within the area covered by the injunction of the Supreme Court, which applied only to the river.

It became important, therefore, to define the territorial limits over which the injunction operated, or, in other words, to ascertain the dividing line between the river and bay. The Governors of the two States interested having referred this question to their respective Attorneys-General for settlement, it was agreed by these officers to accept the decision of the Superintendent of the Coast and Geodetic Survey. The conclusion reached by the Superintendent, and confirmed by Assistant Mitchell, was that the dividing line was properly one from Bombay Hook Point to Cohansey light, a conclusion which, in view of the large interests involved in the controversy, attests the practical value of studies not unfrequently classed as purely speculative.

Assistant Mitchell refers to a report prepared by Assistant Marindin on a comparison of the changes in the transverse sections of the Delaware River between Old Navy-Yard and the east end of Petty's Island, as shown by the surveys of 1819, 1843, and 1878. This report, with illustrative diagrams, appears in Appendix No. 12.

Reference was made in the last annual report to Mr. Marindin's assignment to duty as Consulting Engineer of the United States Advisory Commission for port-warden lines for the harbor of Philadelphia. Until about the middle of October Mr. Marindin was occupied on the comparisons of surveys; he then received a call from the chairman of the Advisory Commission, and after preparing the port-warden lines for discussion, he attended a meeting of the Commission in December. In the early part of January he was directed to collect some data with a view of showing the importance of marking George's Shoals; on this subject he made a special report to Mr. Mitchell, who was then engaged on that inquiry. Subsequently he was ordered to proceed to Washington for conference with the Superintendent, and then to Philadelphia to take charge of a hydrographic and topographic survey of the Delaware River above Bridesburg. He was, however, soon relieved from this duty and directed to prepare for work in connection with the resurvey of New York Bay and Harbor. Mention of this has already been made under a preceding heading in this report.

Upon the Commission advisory to the Harbor Commission of Philadelphia, the Survey is represented also by Mr. Mitchell, to whom was tendered recently the chairmanship. But he deemed it best to decline the position, as it seemed to him that either of his two associates might more properly preside, both being in charge of public works in the neighborhood. Capt. George B. White, U. S. N., was accordingly elected. The third member is Col. Henry M. Robert, United States Engineers. Towards the latter part of June, 1885, Mr. Marindin was informed that he had been elected secretary of the board.

*Special triangulation. Delaware River from Petty's Island to Poquessink Creek.*—An extension of the survey of the Delaware River from Petty's Island to Poquessink Creek, the northeastern boundary of the city, having been requested by the city authorities, Assistant F. W. Perkins was directed to proceed to Philadelphia and execute the work, after conference with Mr. Samuel H. Smedley, Chief Engineer of the city.

Mr. Perkins began a reconnaissance of the ground to be covered early in November, and by the 20th of that month was able to begin observations. Progress being slow, owing to bad atmospheric conditions, Subassistant Van Orden was ordered to report to Mr. Perkins soon after the beginning of December, and with his energetic aid field work was finished by the end of the year. The triangulation determined all the points needed for a topographical and hydrographical survey of the most detailed nature.

Following are the statistics:

| | |
|---|---|
| Number of points occupied | 13 |
| Number of positions determined | 53 |
| Number of observations made | 3,318 |

Assistant Perkins expresses his obligations to Chief Engineer Smedley for many courtesies and liberal facilities in the execution of the work, and to Mr. George S. Webster, surveyor of the tenth district, for much valuable assistance and information.

Other duty assigned to Mr. Perkins is mentioned under the heads of Sections I and VIII.

*Magnetic observations at Philadelphia.*—To meet a request made by the Committee of the International Electric Exhibition at Philadelphia, and for the purpose of following up the secular change in terrestrial magnetism, Assistant Edwin Smith was directed in August, 1884, to determine the magnetic horizontal intensity and the dip at the building for electric tests on each of three days, the special locality to be selected after consultation with Prof. H. B. Snyder, of the Franklin Institute. He was instructed also to reoccupy the old magnetic station of the Coast and Geodetic Survey at Girard College, and to make there the usual three days' observations for declination, dip, and intensity.

After observing five sets of oscillations at the magnetic station on Capitol Hill, Mr. Smith proceeded to Philadelphia, and upon the completion of the necessary arrangements with Professor Snyder, took seven sets of oscillations and three sets of dip at the test laboratory of the exhibition on August 29, 30, and 31.

It was found that at Girard College a new station would have to be selected, the positions of the old stations being either covered with buildings or too near them to admit of obtaining results free from abnormal disturbances. At the station occupied, which was in the grounds and near the one of 1877, complete sets of observation for declination, dip, and horizontal intensity were made on September 3, 10, and 11. The true meridian was determined by four sets of observations on the sun.

The instruments used were the same as those in use for many years past by Assistant Schott at the station on Capitol Hill: Magnetometer No. 7 and Casella dip circle No. 4440. On returning to Washington, Mr. Smith observed three sets of oscillations at the Capitol Hill station.

All of the records and field computations of this work have been deposited in the office.

Other field duty assigned to Assistant Smith will be referred to under the headings of Sections VIII, IX, and XV.

*Determination of the position of a wreck off Barnegat.*—It having been reported to this office that the wreck of the steamer Guadalupe, ashore off Barnegat, was in a position dangerous to navigation, Lieut. Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey, was instructed to determine its position. He dispatched Ensign M. C. Gorgas, U. S. N., with orders to take the necessary measurements, and to board the wreck if practicable. By angles taken from shore stations, the position of the sunken steamer was referred to Barnegat light-house, but on account of heavy breakers Mr. Gorgas was unable to board the wreck or even get near it. As it appeared probable that the vessel would soon be broken up by the action of the sea, it was not deemed advisable to issue a Notice to Mariners.

Lieutenant-Commander Brownson reports that Ensign Gorgas carried out his instructions with zeal and intelligence under difficulties, owing to a heavy gale of wind which prevailed while crossing Barnegat Inlet and at the Light. The work was done late in November.

*Continuation of triangulation and reconnaissance on the New Jersey coast. Magnetic station occupied on that coast, and topographic survey continued.*—At the beginning of the fiscal year, Assistant Charles M. Bache was in the field on the coast of New Jersey, near Townsend's Inlet, under instructions to carry a small triangulation for the purposes of a topographical survey from that Inlet to Absecon light at Atlantic City. Subassistant J. B. Baylor was attached to his party during part of the season. He aided in the triangulation, and determined the magnetic declination, dip, and intensity at a station near Sea Isle City, on Ludlam's Beach.

Beginning with the base-line Tatham–Public, near Townsend's Inlet, Mr. Bache carried the triangulation to Absecon light, a distance of nearly twenty-seven miles, by October 15. Each station of the seventeen triangles laid out was occupied, and each angle measured by four series of observations of six repetitions each.

The stations were for the most part on the edge of the fast land of the coast and inside the sand hills of the beach. Each station was secured by a sub-surface center-mark of 7-inch gas-pipe driven into the ground.

Mr. Bache mentions that a railroad, without break except at Egg Harbor Inlet, has been constructed and is now in running order from Townsend's Inlet to Absecon Inlet, following the beach.

Mr. Baylor was relieved from duty in the party, October 1. His services are referred to in terms of high appreciation by Mr. Bache.

At the close of the season the barge Beauty, which had served as a floating camp for the party, was laid up at Sea Isle City.

During the winter, Assistant Bache completed the field computations and records of his triangulation, and at the opening of the season, in 1885, was directed to organize a party as soon as practicable and resume the topographical resurvey of the New Jersey coast. This work he began a little to the southwest of Townsend's Inlet, and at the end of the fiscal year he was steadily prosecuting it northeastwardly toward Atlantic City. Up to that date the statistics are:

| | |
|---|---|
| Miles of outer shore-line surveyed | 5 |
| Miles of roads | 4 |
| Miles of shore of creeks | 40 |
| Miles of shore of fast-land | 9 |
| Area surveyed in square miles | 6 |

*Topographical resurvey of the New Jersey shore of Delaware Bay continued.*—At as early a date after the beginning of the fiscal year as the appropriation would permit, instructions were issued to Assistant R. M. Bache to resume topographical work on the east shore of Delaware Bay. The two projections, on a scale of 1–20000, furnished to Mr. Bache included the shore-line of the bay from the Hummocks, about two miles south of the mouth of Goshen Creek, to Fortescue Creek. Back of the shore-line the distance included in the survey varied from a mile to a mile and a half. The width of the belt was determined with reference to three considerations—first, the general symmetry of the circumscribed area, regarded longitudinally in view of the very great curvature of the shore; second, the exhibition within that area of the relation to each other of the intersecting river and creeks; and, third, the representation within reasonable limits of the points of fast-land protruding into the wild marsh, thereby completing with other elements the characteristics of the ground. The first sheet, extending from the Hummocks to Egg Island light, was finished; the second, from Egg Island light to Fortescue Beach, was not completed when orders were received November 10 to discontinue work for the season.

Mr. E. L. Taney served as aid in the party, to the entire satisfaction of his chief.

During the winter Mr. Bache finished the inking of his topographical work, and early in June 1885, resumed field operations under instructions to take up the survey at the limit of work of the preceding season. At the close of the fiscal year he was at Nantuxent Creek, having delineated six miles of shore-line with a belt of interior topography of the average width.

The statistics for the fiscal year are:

| | |
|---|---|
| Miles of main shore-line surveyed | 101 |
| Miles of shore-line of creeks | 121 |
| Miles of shore-line of ponds | 20 |
| Miles of shore-line of roads | 33 |
| Area surveyed in square miles | 43 |

*Completion of the topographical resurvey of the western shore of Delaware Bay.*—At the opening of the fiscal year there remained on the western shore of Delaware Bay, to complete the topographical resurvey which had been in progress since 1880, a strip of topography about sixteen miles in length, extending from Clarke's Point Station, four miles north of Mispillion light-house, to Broadkill Creek, and about one mile, on the average, in width.

This work was taken up by Assistant C. T. Iardella, in pursuance of instructions dated July 12, 1884, and was finished October 31.

With regard to Mispillion Creek, Mr. Iardella observes that it is about one hundred and fifty meters (four hundred and ninety-two feet) wide at its entrance. Vessels drawing six feet can enter at very high tide, and after getting abreast of the light-house, ten to fifteen feet can be carried at low water from the light-house to Milford, a distance of twenty-one miles. In some places the creek is two hundred meters (six hundred and fifty-six feet) wide. A shoal, nearly bare at low water, obstructs the entrance; eight or nine vessels have been seen at anchor for nearly a week, waiting for fair wind and high tide, to get over the shoal.

Just below the entrance of Mispillion Creek there is a wide ditch, some two miles long, which connects with Old Cedar Creek. This creek, from its entrance to the ditch or canal, is filled up. Small vessels drawing five feet can pass through the canal, and after reaching the creek the water deepens for a short distance.

Slaughter Creek is entirely filled up at its entrance, and navigation is entirely suspended. At the entrance a shoal has been formed which for about two hundred meters is entirely bare at low tide.

The statistics of the season's work are as follows:

| | |
|---|---|
| Miles of shore-line surveyed | 11 |
| Miles of roads | 12 |
| Miles of marsh-line | 12 |
| Miles of shore-line of creeks and ditches | 11 |
| Miles of shore-line of canals | 7 |
| Area surveyed in square miles | 17 |

*Continuation of the hydrographic resurvey of Delaware Bay and entrance.*—As early in July, 1884, as the appropriation became available, Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, was instructed to organize his party on board the steamer Endeavor, and continue the hydrography of lower Delaware Bay and entrance. For this purpose he was furnished with four projections, three of which were laid out upon a scale of 1–20000, and included areas of hydrographic work extending from the eastern and western shores of the bay north of Cape May light and Mispillion light to the main ship-channel; the fourth, on a scale of 1–40000, included hydrography in less detail between Capes May and Henlopen and off the entrance to the bay.

Great care was taken to establish a sufficient number of tide-gauges to obtain accurate planes of reference for the reduction of soundings. Box and staff gauges were fixed at the steamboat wharf, Cape May Point, and referred to a bench-mark on the beach. A box-gauge was established in the vicinity of Maurice River light-house, and referred to a bench-mark on the foundation wall of the building. Five gauges were set up near Hut Station, six miles nearly northwest of Mispillion light. These gauges were all compared with each other by simultaneous observations to guard against mishap in case of storms. They were also compared with the gauge at the United States iron pier on the Delaware Breakwater, day and night tides being observed at both places for several days.

Lieutenant Hanus, in his report of the season's work, gives full details in regard to the locality of the several gauges established, and the methods followed in obtaining comparisons of readings.

With reference to the mode of planting water signals devised by himself two years ago, and described on page 34 of the Report of 1883, he observes that a large number of these were used in the hydrographic work, and that a long tree, large at the base, was found to be better than a signal made of scantling. One of these trees, forty feet in length, was planted in fifteen feet of water. These tree pump-signals withstood every gale that occurred during the season.

Ensigns A. L. Hall, J. H. Hetherington, E. F. Leiper, and G. R. French, U. S. N., were attached to the party.

Soundings were completed according to the scheme of operations, November 12, and about a week later Lieutenant Hanus took the Endeavor to Norfolk to prepare for work on the Southern coast. Reference to this will be made under the headings of Sections V and VI.

For the Delaware Bay and entrance hydrography, the statistics are:

| | |
|---|---|
| Miles run in sounding | 1,530 |
| Angles measured | 11,022 |
| Number of soundings | 49,813 |

## SECTION III.

### MARYLAND, DISTRICT OF COLUMBIA, VIRGINIA, AND WEST VIRGINIA, INCLUDING BAYS, SEAPORTS, AND RIVERS.

(SKETCHES NOS. 1, 4, 15, 17, AND 18.)

*Gravity determinations and experimental researches at Washington, D. C., and in Virginia.*—Instructions issued to Assistant Charles S. Peirce in July, 1884, directed him to proceed to Fortress Monroe, Virginia, to determine gravity there, and subsequently to reconnoiter for one or two stations suitable for gravity determinations in the mountain region of Virginia, West Virginia, and North Carolina.

Mr. Peirce was occupied at Fortress Monroe till about September 1 in determining the intensity of gravity. He had some difficulty in finding a suitable casemate in which to swing his pendulum, Peirce No. 3. Finally, after making some experiments with the noddy to determine the amplitude of swaying of the pendulum support (see Appendix No. 15, Report for 1884), he swung the pendulum heavy end up and heavy end down on alternate days until an ample number of oscillations had been secured in both positions. With reference to these observations Mr. Peirce remarks, "Peirce No. 3 has therefore been swung in a particularly satisfactory manner, and I consider it unnecessary to swing another pendulum here, owing to the fact of this pendulum being reversible as well as invariable. The results here will be quite as good as at Allegheny."

In September Mr. Peirce reconnoitered for a gravity station in the mountains of Virginia; but no station could be found which would meet the views of the Superintendent as to elevation above the sea-level and at the same time not be too expensive to occupy.

On returning to Washington Mr. Peirce was appointed, October 1, to the charge of the Office of Weights and Measures. The duties of this position he fulfilled till February 22, when he declined further service.

During this time, under instructions, he carried through an elaborate occupation of the initial gravity station at the Smithsonian Institution with four reversible pendulums—"Peirce Nos. 1, 2, 3, and 4."

In November he was directed to attend the meeting at Newport of the National Academy of Sciences, of which body he is a member, and to present there a memoir upon the gravitation and other surveys. Also to attend the December meeting of the American Metrological Society and read a memoir upon the determination of gravity. This memoir will be printed by the society.

During the winter, under instructions from the Superintendent, Mr. Peirce proceeded to Boston, Providence, Hartford, New York, and Philadelphia, and conferred with the manufacturers of gauges and machinery, and also with electricians and others with reference to the resolutions passed by the United States Electrical Conference concerning weights and measures, and the best way of meeting the wants of the country. In January, 1885, he was summoned before the Congressional Commission and testified on the subject.

Towards the end of February, instructions were given to Mr. Peirce to proceed to Key West and make gravity determinations there. Mention of his operations in that locality will be made under the heading of Section VI.

*Annual determination of the magnetic declination, dip, and intensity at the station on Capitol Hill, Washington.*—In order to determine the annual effect of the secular change in the magnetic elements, observations for magnetic declination, dip, and intensity have been made at least once a year during the past thirty years at a magnetic station upon Capitol Hill, Washington, D. C. During that period, the declination has increased gradually from 2° 24′ W. of N. to 4° 12′.

Assistant Charles A. Schott, by whom or under whose direction the observations have been made, observed on June 13 and 15, 1885. The secular variation of the magnetic declination in the United States and at some foreign stations was discussed by Mr. Schott in a paper published as Appendix No. 12 to the Report for 1882. In this Report will appear (Appendix No. 6) Mr. Schott's discussion of the secular variation of the magnetic dip and intensity, based upon observations made within the United States from the earliest to the present time.

*Continuation of the detailed topographical survey of the District of Columbia.*—Favorable progress has been made in the detailed topographical survey of the District of Columbia during the nine months spent by the party of Assistant J. W. Donn in field-work. This survey, made at the request of the Commissioners of the District of Columbia, and carried on since February, 1881, under their general direction, has for its main object, to quote a recent report of the Engineer Commissioner, the supplying "of data for laying out new, and extending old, roads, and for properly subdividing county property as it is laid out in suburban streets and lots.

"But its minute accuracy will make it useful for all time in planning public works of every description. It saved the necessity for the preliminary surveys in connection with the extension of the water-works now in progress, and it will accomplish the same purpose when the city sewerage has to be extended into the country. From the maps of this survey, so far as completed, and from such other data as were available, was compiled during the last year a new map of the entire District on a scale of four inches to the mile, to take the place of the Boschke map of 1855, of which the edition was exhausted, and which, in spite of many errors, was the only topographical map of the District in existence. The new map was handsomely lithographed and printed in four colors by Bien & Co., of New York.

"In connection with this survey, during the past season the four corner monuments of the District, as established by Ellicott in 1791, were identified and located. It was discovered that the District is not exactly a ten-mile square, the length of the four sides being as follows:

"Southwest 53,031.3 feet, or 231.3 feet too long.

"Southeast 52,871.3 feet, or 71.3 feet too long.

"Northwest 52,863.6 feet, or 63.6 feet too long.

"Northeast 53,063.8 feet, or 263.8 feet too long.

"The total area of the original District was 100.6 square miles. The north point is 116.6 feet west of the meridian of the south point, and the east point is 138.6 feet south of the west point. Considering the character of the instruments with which Ellicott made his survey, and the nature of the country, then practically a wilderness, through which he ran his lines, one cannot but be surprised at the accuracy of his results.

"From the data already furnished by this survey preliminary plans have been sketched out for the extension of the following avenues and streets through a portion of the county, viz, Massachusetts, Vermont, New Jersey, and Rhode Island avenues, Sixteenth street and L street. Other demands upon the District revenues make it impossible to attempt to carry these plans into effect at the present time; but the property-owners are recognizing the importance of having suburban property systematically laid out, and show a willingness to follow these plans in the subdivision of their property. By so doing the city will be saved the expense in the future of rectifying irregular street lines in the suburban district at a cost far exceeding the expenditures for this survey, which are only $5,000 a year."

At the beginning of the fiscal year the survey had been advanced to Blagden's mill, in Rock Creek Valley, and thence along the road leading to Brightwood, and up the Seventh street road to Silver Spring and the crossing of the northeastern boundary of the District. Westward of Rock Creek Valley the work was completed from Woodley Lane at Woodley Park to the northeastern boundary stone of the new Observatory site, thence across the western extremity of Georgetown Heights to the Distributing Reservoir and to the Potomac River.

During the summer of 1884 Mr. Donn worked west of the Seventh street road, north of the Blagden mill road, and across the valley of Rock Creek above the crossing of the Military road. Much of this area was occupied by a region very difficult of access on account of heavy undergrowth. The survey was extended to the table-land lying between Rock Creek Valley and the valley of Broad Creek, and as far westward as it was possible to go during the season of foliage. This northwest corner of the District presents some great difficulties to be overcome, in the shape of almost impenetrable thickets of spruce pine covering considerable areas.

In November, after completing some work called for by the Commissioners, lying to the eastward of the Metropolitan branch of the Baltimore and Ohio Railroad, Mr. Donn transferred his survey to the country in and adjacent to the Foundry Branch Valley above Georgetown, embracing the Georgetown College grounds, and as far up the valley as Tunlaw road. The several triangulation points established along the northwest boundary line of the District were occupied, and many points determined for the needs of the survey.

During January and part of February the survey of Rock Creek Valley was completed from Blagden's mill to the crossing of the Military road, and during the latter part of February and March the valley lying immediately north of the grounds of the new Naval Observatory was surveyed from the northeast corner of that property to the Tenallytown road.

By the end of March, as there remained only enough of the appropriation to defray the cost of completing such drawings and photolithographs as were required by the Commissioners, field-work was abandoned. In April Assistant D. B. Wainwright, who had rendered most efficient service in the party, was detached for other duty, reference to which has been made under the heading of Section II. The preparation of sections of the survey for photolithographing was continued by Mr. J. A. Flemer, the draughtsman of the party. Tracings from the original sheets were prepared as needed by Mr. Donn. On the 22d of June, a small surplus having been found to be available, Mr. Donn took the field, and at the close of the fiscal year was at work extending the topography along Woodley Lane to its junction with the Tenallytown road.

*Lines of leveling of precision carried from Ashland, Va., to Fortress Monroe; also a line to connect the bench-mark near the Washington Aqueduct Bridge with the Capitol bench-mark.*—It was stated in the last annual report that the lines of leveling of precision in progress from Hagerstown, Md., towards Fortress Monroe had been carried at the close of the season in 1883 to a bench-mark established on the Duncan Memorial Chapel at Randolph and Macon College, Ashland, Va.

In pursuance of instructions issued in September, 1884, work on these lines was resumed by Assistant J. B. Weir, September 23. The Richmond, Fredericksburg and Potomac Railroad was followed as far as Richmond, Va. In passing through that city, streets were selected for the route of the levels that were least used, and at times the work was done early in the morning before any jar from heavy teams was noticeable. From the Richmond, Fredericksburg and Potomac Railroad the descent to the Chesapeake and Ohio Railroad was forty-three and six-tenths meters (one hundred and forty-three feet), although the horizontal distance passed over in the line of levels was only four and two-tenths kilometers, or two and six-tenths miles.

About three hundred meters (nine hundred and eighty-four feet) from the depot of the Chesapeake and Ohio Railroad there is a tunnel, which is fourteen hundred meters (four thousand five hundred and ninety-three feet) long; and about eight hundred meters (two thousand six hundred and twenty-five feet) from the eastern end of this tunnel is a high trestle of about the same length as the tunnel. The proximity of these two obstacles made it difficult to follow the line of the railroad, but by taking a somewhat circuitous route through streets and along the York River Railroad Mr. Weir succeeded in going round both the tunnel and trestle with but little loss of time. A point was thus reached on the Chesapeake and Ohio Railroad at the eastern edge of the city, and the line of levels was continued thence along the same road to Fortress Monroe without meeting any serious obstacle.

At Fortress Monroe the line of levels was connected with the bench-mark on the light-house, this being the bench to which the tide-gauge was referred during the period that tidal observations were made at that point. Connection was also made with a bench-mark on the fort near the postern gate, and a permanent bench-mark on the Soldiers' Home in Hampton.

Full descriptions of these bench-marks accompany the records and computations which have been transmitted to the office. The field computation will require to be checked by the office computation before an accurate comparison can be made between the tidal levels at Sandy Hook and Fortress Monroe.

After finishing the work just referred to, Mr. Weir, under instructions, ran a line of levels to connect the bench-mark near the Washington Aqueduct Bridge with the Capitol bench-mark.

Mr. John Nelson served as acting aid in the party very acceptably.

Other lines of leveling of precision run by Mr. Weir during the spring of 1885 will be referred to under the heading of Section XIV.

*Determination of points on the boundary line between Maryland and Virginia.*—Application having been made by the Governors of Maryland and Virginia for the detail of an officer of the Coast and Geodetic Survey, who should mark and determine in geographical position two points on the boundary line between their respective States, in the presence of Mr. William J. Aydelott, Commissioner on the part of Maryland, and Mr. George H. Bagwell, Commissioner on the part of Virginia, instructions were given November 17, 1884, to Mr. Charles Junken, Acting Assistant, to meet the commissioners for the purpose just indicated.

On December 1, the steamer Governor McLane, under command of Capt. H. Thompson, of the Maryland fishery force, was placed at the disposal of the Commissioners, and was retained by them until the weather became so stormy and inclement that they deemed it advisable to postpone the completion of the work till spring, only five working days having been obtained between December 1 and 23.

The points to be marked were in Pocomoke Sound, at a distance apart of two and a half miles (nautical), and in seven and twelve feet water, respectively. From three shore stations, known in position, Mr. Junken established two groups of permanent range marks, each group having two front signals and one rear signal; these signals were placed on the north shore of the sound, one group to the east, the other to the west of Apeshole Creek. By means of the range signals the places of the two points on the boundary line were readily found, and marked temporarily with quarter-inch iron pipe.

In May 1885, Mr. Junken again met the commissioners to complete the work. At the most southern point in the line, about two and a half miles (nautical) from the mouth of Broad Creek, he anchored a third-class can buoy in eleven feet water, soft bottom. The buoy was painted white, and was secured by a second-class stone sinker with fifteen fathoms of chain. This was done on the 20th of May, and on the same day a six-inch galvanized iron pipe thirty feet long, with steel driving-point, was sunk nineteen feet into the ground, in seven feet of water, at the more northern point in the line, about a mile and a half (nautical) west of the entrance to Pocomoke River. At this point the bottom is of soft mud, with a hard top-crust of sand and gravel of two feet in thickness. To the top of the pipe is secured a cap made of hoop-iron, forming a skeleton sphere of sixteen inches in diameter, with the letters "MD." "VA." attached.

For the front and rear range signals underground marks were placed in position.

Before returning to the office, Mr. Junken determined trigonometrically the positions of

James Island light and Somers Cove light. In his report he expresses his thanks to the Commissioners and to Captain Thompson for their uniform courtesy.

*Hydrographic examinations off Cape Henry, Virginia.*—Upon the completion of hydrographic work in Long Island Sound, which has already been referred to under the heading of Section II, Ensign A. F. Fechteler, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner Ready, was directed to proceed to Cape Henry, Virginia, and make an examination of the shoal upon which the U. S. S. Ossipee grounded. The soundings as given on the chart, he was to connect with the shore-line, and continue examinations south of the cape.

This work was completed by Ensign Fetcheler about the middle of December, though only by great persistence in the midst of frequent interruptions from stormy weather. No changes were found of sufficient importance to involve alterations upon the chart.

*Supplementary topographical survey between Norfolk and the ocean shore.*—Some details of topography yet remaining to be completed between Lynnhaven River, Virginia, and the sea-coast, in furtherance of this work Assistant Eugene Ellicott was sent to Norfolk towards the end of November, 1884. The season proved unfavorable; cold, wet, and stormy weather in December retarded field operations, and early in January the party was disbanded. Mr. Ellicott reports thirteen miles of roads surveyed, and an area of thirteen square miles. Mr. J. H. Gray was attached to the party as aid.

Towards the end of April, 1885, Mr. Ellicott resumed this work under instructions and completed it on the 19th of May.

Other surveys made by Mr. Ellicott are referred to under the headings of Sections I and VI.

*Extension of the primary triangulation near the thirty-ninth parallel from West Virginia into Kentucky and Ohio.*—At the beginning of the fiscal year Assistant A. T. Mosman was in the field making the needed preparations for extending the primary triangulation westward near the thirty-ninth parallel from the points previously occupied by him in West Virginia. On the 16th of July, 1884, he established his camp at Station Wray, in Lawrence County, Ohio, about sixteen miles east of Ironton.

At this station an observing tripod had been erected eighty feet in height. Heliotropes were posted at Stations Davis, in West Virginia, and Oakland, in Kentucky, and the signal at Gebhardt, West Virginia, was visited and verified; but, owing to unfavorable weather, no observations were obtained till August 5. Meantime, it having been found that the line Wray–Buena Vista was not practicable on account of an intervening ridge, a change of scheme of triangulation became necessary, and after finishing observations on the stations to the eastward a reconnaissance was begun August 21, and the country between Wray and Buena Vista thoroughly explored. At the beginning of this reconnaissance, and in the observations preceding, Mr. Mosman had the skillful and energetic aid of Prof. J. H. Gore, of the Columbian University, who served in the party as volunteer assistant from August 6 to August 23.

A point called Tradd was finally selected on the ridge to the westward of Wray. From Tradd five of the primary stations were visible. Mr. Mosman returned to camp September 1. During his absence Mr. J. E. McGrath, aid, had reported for duty. By September 6 the angles remaining had been measured at Wray, and on the 7th the theodolite was mounted at Gebhardt Station, in Cabell County, West Virginia, about twenty miles north of Huntington. The direction from Gebhardt to Tradd was quickly determined, and on September 9 preparations were begun for occupying Station Oakland, Boyd County, Kentucky, six miles south of Catlettsburg.

At this station the theodolite was mounted upon a tripod forty-five feet high. A similar tripod was erected at Tradd by E. E. Torrey, foreman, and the line between Oakland and Tradd was opened by Mr. McGrath. Observations at Oakland were begun September 16. Mr. P. A. Mosman, who acted as recorder from the beginning of the season, left September 25, and Mr. W. B. Fairfield, extra observer, reported for duty on the same day. Work at Oakland was finished October 2, and preparations were then begun for moving to Buena Vista, about sixteen miles south of Greenup, Ky., in the county of that name. While the moving was in progress Station Tradd was occupied by Extra Observer W. B. Fairfield, who measured approximate angles there with an eight-inch theodolite on Oakland, Buena Vista, and Wray.

At Buena Vista the large theodolite (No. 118) was mounted on a concrete pier October 12.

Signals of sixty-five feet at Howland Station, and thirty feet at Cave Station had been erected and heliotropers posted. By October 23 all of the observations needed at Buena Vista had been obtained. The camp equipage was then stored at Franklin Furnace; the party disbanded, a driver only being retained, and preparations were made for continuing the reconnaissance to the westward.

As the country through which it was carried—the counties of Scioto and Adams, Ohio, bordering on the Ohio River—is very broken, thinly inhabited, and with but very few roads, much difficulty was experienced in carrying on the work. It was found necessary to erect a tripod and scaffold one hundred feet high at Scioto Station, about four miles northwest of Portsmouth. On November 10, reconnaissance angles were measured from the top of this tripod. Meanwhile a station on Cherry Ridge, back of Concord, Ky., had been selected. This point occupied a commanding position, giving a very fine view to the northward and westward.

The weather continuing unfavorable, Mr. Mosman, after examining the difficult country between the headwaters of Blue Creek, Churn Creek, and upper and lower Twin Creeks for a central station decided to make a general examination of the country between Rome, on the Ohio River, and West Union, the county seat of Adams County, which is situated on a high ridge and occupies the highest ground in the vicinity. From the top of a lofty building in this town, a ridge near Mineral Springs, Ohio, was found to be the most commanding position from which to see Scioto, Cherry Ridge, and the hills at the head of Twin Creek.

Mineral Springs was visited November 22, and between that date and December 22 the reconnaissance was steadily prosecuted by Mr. Mosman, much of the time through a heavily-wooded country, crossed by ridges of nearly equal height, and with not a few interruptions from snowstorms and intensely cold weather, with high winds. His report of the work is accompanied by a sketch showing the scheme of triangulation found most practicable.

In addition to the two gentlemen already referred to as having served in the party, Assistant F. D. Granger was attached to it from September 26 to October 6. Extra Observer W. B. Fairfield was ordered to the party July 1, but owing to illness was unable to take the field till September 25. He was detached November 10. Mr. P. A. Mosman served as recorder till September 25, acting also for a time as foreman in moving and pitching camp, posting heliotropers, &c.

Mr. Mosman refers in terms of cordial appreciation to the interest in the work taken by the officers of his party and to their constant and zealous efforts for its advancement. He acknowledges also the efficient labors of his foreman, E. E. Torrey.

Statistics of the season are:

| | |
|---|---|
| Primary stations occupied | 4 |
| Observing tripods and scaffolds erected (heights of 30, 45, 65, 100 feet) | 5 |
| Primary stations selected in reconnaissance | 5 |
| Number of primary objects observed | 20 |
| Number of observations on primary objects | 1548 |
| Number of secondary objects observed | 2 |
| Number of observations on secondary objects | 13 |

The records of the work, original and duplicate, and the field computations have been transmitted to the Office.

## SECTION V.

SOUTH CAROLINA AND GEORGIA, INCLUDING COAST, SEA-WATER CHANNELS, SOUNDS, HARBORS, AND RIVERS. (SKETCHES NOS. 1, 5, 17, AND 18.)

*Hydrographic survey in the Stono and Wadmelaw Rivers, South Carolina.*—Some additional soundings being required to develop the hydrography of the inland passages which connect Charleston Harbor and North Edisto River, Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Arago, was directed to execute this work. The Stono and Wadmelaw Rivers are in many places very narrow and full of shoals, and it was found necessary to take soundings rapidly. As but three points of the old triangulation could be found near one end of the work, and but two at the other, it became necessary to lay out a small triangulation. This closed exactly upon the old points.

To obtain a well-determined plane of reference for the soundings, five tide-gauges were established between Martin's Point on Wadmelaw River and Elliott's Cut, Stono River, a distance of nineteen miles. As no station could be occupied during a lunar month, all gauges were compared with the self-registering gauge of the United States Engineers at Fort Sumter, where consecutive tides had been observed for a year or longer.

Lieutenant Hanus had the aid of the following-named officers: Ensigns E. F. Leiper, F. R. Brainard, and George R. French, U. S. N.

In March, 1885, the hydrography was completed and the following statistics reported:

| | |
|---|---|
| Miles run in sounding | 214 |
| Angles measured | 3,335 |
| Number of soundings | 30,899 |

Early in April, in pursuance of instructions, Lieutenant Hanus took up hydrographic work on the Saint John's River, mention of which will be made under the heading of Section VI.

## SECTION VI.

PENINSULA OF FLORIDA, FROM SAINT MARY'S RIVER, ON THE EAST COAST, TO AND INCLUDING THE ANCLOTE KEYS ON THE WEST COAST, WITH THE COAST APPROACHES, REEFS, KEYS, SEAPORTS AND RIVERS. (SKETCHES Nos. 1, 6, 7, 17, and 18.)

*Triangulation and shore-line topography of Saint John's River, from Nine-Mile Point to Palatka.*—In continuation of the survey of the Saint John's River, Florida, Assistant Eugene Ellicott was directed to proceed to Jacksonville, Fla., and await there the arrival of the schooner Ready. In March, 1885, he sailed to Nine-Mile Point, about twenty miles below Palatka, and began a triangulation of the river. Upon the 17th of March this work was finished to the Devil's Elbow at the head of the broad easily navigated part of the river, and about two miles above Palatka. The shore-line topography was then taken up and carried over the same ground. It was deemed desirable to postpone filling in details of topography in view of the expected early arrival of the hydrographic party. Mr. Ellicott states that the Saint John's is navigable for ocean steamers to San Mateo, eight miles above Palatka, and that he thinks they go still further up when freights are offered. Traffic on the river is large, and the demand for a chart of the portion then under survey very great. From the entrance to Racy's Point, just above Nine-Mile Point, a chart of the Saint John's has been published in four sheets.

Much of the shore-line survey had to be done with the plane-table standing in from one to two and a half feet of water, and certain parts of the shore line are outlined only by an edge of cypress trees, the water extending back for an apparently indefinite distance. From the Devil's Elbow, a sextant triangulation was carried, and an approximate shore line delineated as far as San Mateo.

On the 15th of April Mr. Ellicott, in accordance with instructions, turned the Ready over to Lieutenant Hanus, U. S. N., Assistant Coast and Geodetic Survey, and the next day proceeded northward.

Duty subsequently assigned to him has been referred to under the headings of Sections I and III.

*Hydrographic survey of Saint John's River from Racy Point to Palatka.*—Upon the completion of the triangulation and shore-line topography of the Saint John's River between the limits mentioned under the previous heading, Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Arago, began a hydrographic survey extending from Racy Point (just above Nine-Mile Point) to San Mateo, about four and one half miles (by the river) below Palatka. On the 16th of April, Lieutenant Hanus was detached from the party for other duty, and in pursuance of instructions transferred the command of the Arago to Ensign E. F. Leiper, U. S. N., Assistant Coast and Geodetic Survey, under whose direction the work was completed.

At the beginning of the survey, the river was almost two miles wide, and lines of soundings about three hundred meters (nine hundred and eighty-four feet) apart were run as nearly normal to the shore as practicable. As the width of the river decreased the lines of soundings were run closer.

The time allowed for the work being very short, no attempt was made to sound out the creeks;

only two of these, however, were navigable, Deep Creek and Rice Creek. A sextant triangulation having been made in advance by the topographical party, and an approximate shore line determined as far as San Mateo, the hydrography was completed to that point.

A plane of reference for the soundings was determined by observations with a box-gauge secured to one of the piles of the wharf of the Tropical Hotel at Palatka. Tides were observed during thirteen days and twenty consecutive low waters taken. A bench-mark was established on the post of piazza of the hotel. The mean rise of tides observed was nine-tenths of a foot.

Ensign Leiper had the aid of Ensigns F. R. Brainard and G. R. French, U. S. N. He reports the following statistics of the survey:

| | |
|---|---|
| Miles run in sounding | 252 |
| Angles measured | 3, 154 |
| Number of soundings | 17, 574 |

Before the work was finished Ensign Brainard was sent north in charge of the schooner Ready, which had been turned over by the Assistant in charge of the topographical party. Ensign Leiper was directed to proceed to New York upon the completion of his survey and report for duty on board the steamer Endeavor.

*Deep-sea soundings in Northwest Providence Channel and in the Gulf Stream off Florida coast, and subcurrent observations in the Gulf Stream between Fowey Rocks and Gun Cay, Bahamas.*—Early in December, 1884, Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, was detached from duty in the office of the Hydrographic Inspector and directed to proceed to New York and relieve Lieut. Commander W. H. Brownson, U. S. N., Assistant in the Survey, of the charge of the steamer Blake and hydrographic party aboard that vessel. Under Lieutenant Pillsbury's command, the Blake was brought to Washington in pursuance of additional instructions, and fitted for deep-sea sounding and current work off the Florida coast.

The Blake left Washington February 6, 1885, and arrived at her working ground February 18. She left the Florida coast at the close of the season, June 2, reached Charleston, S. C., June 4, and convoyed the Coast and Geodetic Survey steamer Arago north.

Lieutenant Pillsbury has submitted a full report (Appendix No. 14) of his season's work, which was a remarkably successful one. Five lines of soundings were run in the Gulf Stream to the southeast of Cape Canaveral, two lines of soundings across the stream between Cape Florida and Jupiter Inlet, and three lines in Northwest Providence Channel between Bahama Island, Great Abaco, and Great Bahama Bank. Tidal observations were made during six weeks with a box-gauge established at the Fowey Rocks light-house.

Seventeen stations were occupied for current observations in the Gulf Stream between Fowey Rocks and Gun Cay, Bahamas. For the observation of subcurrents a current meter was invented and constructed by Lieutenant Pillsbury. One of the conditions of the successful use of this meter was that the steamer should be safely and expeditiously anchored at sea. For this purpose a steel wire rope of five-eighths and three-fourths of an inch in diameter was used instead of chain or manilla. This wire rope was carried on a large reel and led from that to the drum of the hoisting engine, and from thence through a large iron pulley at the end of a spar over the bow. This spar was hinged at its inner end to a heavy post in the bow and its outer end was held up at an angle of forty-five degrees by a steel wire rope or topping lift, leading over the masthead and to the deck aft. Interposed in this topping lift was an arrangement of rubber buffers, about eight feet in length, designed to take up the slack and relieve the sudden strain on the anchoring rope as the vessel pitched. With this gear the Blake could be anchored in four hundred fathoms in about fifteen minutes, and could get under way in about forty-five minutes.

The current meter consisted of (1) a system of cones revolving around an axis, and registering by means of differential wheels; (2) a freely moving rudder; (3) a compass; (4) an arrangement of wings or fins by which the compass needle and rudder are clamped at the instant of beginning to pull the meter upward through the water; and (5) a propeller which locks the needle and rudder after they have been clamped by the fins, by a continuation of the upward movement.

The meter was lowered by a steel wire, and, in order to keep it from being swept astern by the current, it was attached by a roller to another wire called a jackstay, down which it was free to move. This jackstay wire was anchored on the bottom and kept up and down by weights.

Lieutenant Pillsbury states that the meter worked well, and believes that its results may be accepted with confidence.

The plan proposed for the season's work was to take a series of current observations with soundings at stations between Gun Cay, Bahama Banks, and Fowey Rocks, Florida, followed by a similar series between Yucatan and Cuba, and then to repeat the first series.

Results derived from the first series seemed to indicate that tidal action was more marked than had been supposed; that the axis of the stream was not where it had been put by the old observations, and that the greatest velocity was at or very near the surface.

These results led Lieutenant Pillsbury to ask that his original instructions should be modified so as to confine the current observations to the Florida cross-section. Five principal current stations were accordingly occupied between the Fowey Rocks and Gun Cay. These stations were at about equal distances from each other and from the land on either side. Four of them were occupied during periods of from forty to seventy hours each, and one, situated about eight miles from Fowey Rocks, over four hundred hours.

Quoting from Lieutenant Pillsbury's summary report:

"The record shows, first, that there is a diurnal variation in the velocity of the stream, amounting in some instances to nearly two knots, and that this variation extends to the subcurrents as far as observed (one hundred and thirty fathoms).

"Second. That there is a monthly variation in the velocity, amounting to about three knots, with the conditions of the sun and moon both having great declination.

"Third. That the axis of the stream at this portion of it is probably not in the position supposed by Professor Bache, but is situated more to the westward. The exact position could not be determined in the time allotted to the work.

"Fourth. That the direction of the upper currents, at three and a half, fifteen, and thirty fathoms, remained approximately north. The sub-currents at sixty-five and one hundred and thirty fathoms changed somewhat in direction with the diurnal variation in velocity, often as much as five points on either side of the meridian, and in one or two instances at one hundred and thirty fathoms the rudder indicated a southerly current. This, however, was at the shoaler anchorage, two hundred fathoms in depth, and with a velocity of but a tenth or two, and it is possible that with such a weak current the instrument was in error, although there was no evidence that such was the case.

"Fifth. That the velocity of the subcurrents was in some instances greater than that of the surface current, but the mean of about an equal number of observations on the principal stations, as well as the mean of all the observations on the long station, showed a less velocity in the subcurrents. A continuation of the vertical curves below the point of the greatest depth observed seems to indicate that there is no current at the bottom, but this conclusion may be changed by a complete discussion of the observations on some of the stations."

These results are of great interest as a contribution to our knowledge of the currents of the Gulf Stream, and similar observations carried through another season with the experience gained by Lieutenant Pillsbury will add to their value.

The following named officers were attached to the Blake: Ensigns A. F. Fechteler, P. J. Werlich, W. A. Thom, William Truxtun, E. Simpson, and M. C. Gorgas, U. S. N.

The statistics of the season are reported as follows:

| | |
|---|---|
| Miles run in sounding | 577 |
| Number of soundings | 152 |
| Number of specimens of sea-bottom preserved | 87 |
| Current stations occupied | 17 |
| Total number of current observations with the current meter at depths of two, three and a half, fifteen, thirty, sixy-five, one hundred and thirty, and two hundred and ten fathoms | 1,059 |
| Total number of surface observations | 2,326 |
| Greatest depth of anchoring at any station ... fathoms | 470 |
| Least depth of anchoring at any station ... fathoms | 200 |
| Number of current bottles thrown overboard | 48 |

While at Key West, in March, 1885, Lieutenant Pillsbury rendered an important service to the steamer Alamo of the Mallory line, which had run ashore on Southwest Reef, Tortugas, in a very dangerous position. Learning this, he went at once to her assistance, and although the light-house tender Laurel was already doing her utmost to get the Alamo off, and the Blake aided the Laurel in towing at high water, their united efforts were unavailing during five trials. An anchor was then planted on the port bow of the vessel to haul it to windward, and on the sixth trial the revenue steamer Dix, which had arrived to render aid, hauling on the port quarter, and the Laurel and Blake pulling astern, the Alamo came off practically uninjured. In the work of relief the deep anchoring gear of the Blake was of great service.

At the close of the season the Blake was taken to Hampton Roads, and thence to Boston, to be prepared for work on the New England coast. Duty on that coast, assigned to Lieutenant Pillsbury at the beginning of the fiscal year, has been already referred to under the heading of Section I.

*Determination of gravity at Key West.*—Towards the end of February, 1885, in pursuance of instructions, Assistant C. S. Peirce proceeded to Key West, Fla., to determine the intensity of gravity. Authority having been obtained from the Secretary of War, a station was selected in the barracks at Key West. Pendulum No. 2 was set up and oscillated, heavy end up and heavy end down. The usual transits for time were observed. Mr. Peirce has reported as a preliminary result from his field computations that gravity is in excess on Key West relative to Washington by an amount producing $1^{s}.46$ error in a clock per diem.

Field operations were completed at Key West station by the 1st of May. Mr. W. B. Fairfield, extra observer, took part in all of the observations. In his report Mr. Peirce speaks in terms of the highest commendation of Mr. Fairfield's services.

Referring to the fact that the residual difference of gravity between Washington and Key West is somewhat smaller than he had anticipated, Mr. Peirce expresses the opinion that the question to which gravity research should be directed more particularly for the present is, whether lines of equal residual gravity can be traced upon the map, or whether the merely local variations will mask those that are progressive, and that for this purpose lines ot stations a thousand miles or so in length should be run with stations three degrees apart. But that a north and south line will never afford so clear a proof of the existence of progressive variation in the residual gravity as an east and west one, because with the former there would always remain a doubt whether the assumed latitude correction was right for this part of the world, and though its being different in different parts of the globe would necessarily imply progressive variation along the circles of latitude, yet that might be so slow as not clearly to show itself, say in a thousand miles, without which curves could hardly be drawn. The first endeavor should therefore be to run an east and west line.

*Beach measure and topography on the west coast of Florida from Bowditch Point to Cape Romano.*—In continuation of the survey of the west coast of Florida, from the vicinity of Punta Rasa towards Cape Sable, Assistant Joseph Hergesheimer was directed to organize his party for beach measure and topography on board the schooner Quick.

The Quick was got ready for sea at as early a date as practicable, and reached Punta Rasa, with Mr. Hergesheimer and party on board, December 18, 1884.

The topography of the beach and inlets was begun at Bowditch Point, about three and a half miles south of Punta Rassa, and was completed to Wiggins Pass, a distance of about twelve miles, by December 26. Leaving Punta Rasa on the 29th, Mr. Hergesheimer anchored the schooner the next day in Big Marco Pass, and began the beach measure and topography from Wiggins Pass to Cape Romano, thirty-three miles.

As determined by this work, the geographical position of Cape Romano is a preliminary one, but sufficiently correct for topographic or hydrographic purposes. From Caximbas Pass to Cape Romano the distance was carefully measured twice with a twenty-meter chain.

Unusually stormy weather prevailed during the season, there being a succession of northers with lower temperatures than had been known in that locality for many years. Field operations were closed March 28.

Before leaving the field, Mr. Hergesheimer furnished Lieutenant Heald, commanding the steamer Bache, with the geographical position of the points needed for his hydrographical work on that coast.

The Quick was laid up in Manatee River, in charge of a competent ship-keeper, at the close of the season.

Mr. J. Henry Turner, Aid, joined the party January 27, and rendered efficient service during the remainder of the season.

Mr. Hergesheimer states that the only anchorages for a vessel drawing between five and eight feet of water between Punta Rasa and Cape Romano are Big Carlos and Big Marco Inlets. Big Marco is a good harbor; there are from eight to ten feet of water on the bar, and the channel was wide enough for the Quick to beat in.

The statistics are:

| | |
|---|---|
| Points determined | 77 |
| Angles measured | 124 |
| Number of observations | 1,057 |
| Number of miles of beach measurement | 33 |
| Miles of coast line surveyed with adjacent topography | 41 |

Duty assigned to Mr. Hergesheimer later in the year is reported under the heading of Section II.

*Hydrographic survey of the west coast of Florida from the vicinity of Gordon's Pass to Cape Romano.*—Upon being relieved from the command of the schooner Eagre, towards the end of November, 1884, Lieut. E. D. F. Heald, U. S. N., Assistant Coast and Geodetic Survey, was directed to take command of the steamer A. D. Bache, and prepare her for service in southern waters. A month later, a hydrographic party having been organized on board the Bache, and the vessel having been made ready for sea, Lieutenant Heald received instructions to execute hydrographic work on the coasts of Alabama and Louisiana and on the west coast of Florida. The first named work having been completed, the Bache arrived off the Florida coast early in May, 1885, and began the hydrographic survey from the southern limit of Lieutenant Mansfield's work in 1884, near Gordon's Pass. Lieutenant Heald's survey was based upon points determined and shore line furnished by Assistant Joseph Hergesheimer, then at work on that coast. From Gordon's Pass to Cape Romano, the southern limit of Lieutenant Heald's survey, ship lines of soundings were run one mile apart to develop the ten-fathom curve, and from the boats lines were run one-quarter of a mile apart to develop the three-fathom curve.

Information having been received at this office from Mr. P. L. Cosgrove, master of the lighthouse tender, Laurel, of the existence of an uncharted reef between Marquesas Rock and Coal-Bin Shoal, Lieutenant Heald was directed to examine the locality. He found a shoal on a line joining Marquesas Rock with Coal-Bin Shoal, and on the following bearings:

Marquesas Rock, west one and a quarter miles.

Coal-Bin Shoal, east five and three-eighths miles.

Western extremity Marquesas Keys, north one-half east six miles.

The least water found was sixteen feet. It is situated on the crown of the Florida Reefs, and is named Cosgrove Shoal, after the person who first announced it.

A notice to mariners was issued, reporting the result of Lieutenant Heald's examination. In this, as in similar notices issued by this office, all bearings are magnetic, all distances in nautical miles, and all depths at mean low water.

Ensigns T. D. Griffin, J. M. Orchard, A. Jeffries, W. C. Canfield, and J. E. Craven, U. S. N., were attached to the party.

Statistics of the work off the Florida coast are:

| | |
|---|---|
| Miles run in sounding | 511 |
| Angles measured | 804 |
| Number of soundings | 8,744 |

Towards the end of May Lieutenant Heald proceeded north in the Bache, under instructions to prepare for work on the coast of Maine.

## SECTION VIII.

### ALABAMA, MISSISSIPPI, LOUISIANA, AND ARKANSAS, INCLUDING GULF COASTS, PORTS, AND RIVERS.

(SKETCHES Nos. 1, 5, 8, 17, and 18.)

*Continuation of reconnaissance for the connection of the triangulation of the Gulf coast with that along the Blue Ridge.*—Reference was made in the last annual report to a reconnaissance carried southwesterly from stations in Northern Alabama by Assistant O. H. Tittmann, under instructions to ascertain the most practicable route for extending the Blue Ridge triangulation to the Gulf of Mexico. In November, 1884, Assistant Tittmann was directed to resume this work, and to begin in the vicinity of Mobile. His plan was to examine in detail the country in the immediate vicinity of that port, to reconnoiter the valley of the Alabama River, and to continue the selection of points in the more northern portion of the State, determining the geographical positions of these points with some accuracy.

Leaving Washington December 4, Mr. Tittmann began his reconnaissance at Spring Hill, six miles west of the city, having previously had a consultation with Prof. Eugene A. Smith, State geologist. Professor Smith's knowledge of the country to be traversed enabled him to communicate valuable information which was most freely and courteously accorded.

An examination of the Alabama River as far as Selma was made, and notes taken of the country, as also of localities near Mobile and in the vicinity of Mount Vernon, the site of the United States barracks of that name, thirty miles north of Mobile. There is a crest of hills at this point rising to a height of about one hundred and eighty feet above tide-level. On the eastern side of the river the hills attain a height of about three hundred feet. On both sides they are covered with heavy growths of pine. Mr. Tittmann reports that the most feasible method of conducting the work from Mobile to Choctaw Bluff in Clark County, a distance of fifty miles, would be by a scheme of triangulation involving long lines on the west side, and forming the bases of overlapping triangles, the sides of which would be carried by diagonals to points across the river. Quadrilaterals could doubtless be formed if time enough were given for the selection of the points.

Mr. Tittmann resumed the reconnaissance in the northern part of the State about the middle of February, and has submitted a sketch showing the plan of a proposed triangulation. Much delay was occasioned by the unusual dryness of the season, which caused an accumulation of smoke from the burning of brush and leaves in the woods. At the beginning of May, field operations were closed.

Mr. George F. Bird served efficiently as aid in the party. Early in June, Mr. Tittmann was assigned to duty, reference to which has been made under the heading of Section II.

*Hydrographic work in Mobile Bay and around the Chandeleur Islands.*—An examination of the newly dredged channel in Mobile Bay having become necessary in order to correct the published charts of that locality, and it being desirable to ascertain the nature and extent of other changes reported to have taken place in the bay, Lieut. E. D. F. Heald, U. S. N., Assistant Coast and Geodetic Survey, was instructed to organize a hydrographic party on board the steamer A. D. Bache for the execution of that work.

The dredged channel varies in width from one hundred and fifteen feet to two hundred feet, and in depth from fifteen and a half to twenty-two feet. It extends from the city of Mobile to the Lower Fleet in Mobile Bay, and is indicated by clusters of piles, fifty-one in number, one half a mile apart on the eastern side, the center of the channel being one hundred feet west of the line of piles. In March, 1885, Lieutenant Heald began his survey by determining the direction of this channel and the positions of the beacons and clusters of piles which are intended as permanent "aids to navigation."

All of these were located and plotted upon the projection. Lieutenant Heald states that it is the intention of the Light-House Board to place a light at the south entrance in the position of Cluster No. 51.

The lower portion of the channel, where the least depth is found, is now being redredged, and will soon have a depth of eighteen feet. Owing to the nature of the bottom, which is a soft mud, great difficulty is found in keeping a permanent depth. The tendency in the upper part of the channel is to deepen it.

Quite rapid and important changes have taken place in the topography at the mouth of the bay. Pelican Island has completely disappeared, leaving only a small shoal with one to two feet water upon it. East and West Sand Islands have been connected, and the single island thus formed is gradually extending to the northwest. Two new islands, named, respectively, Coffee and Dixie, have been formed on the sand-banks on the east side of the entrance, and are about one foot above high water. All of these changes were carefully located on the hydrographic sheet.

Upon closing work in Mobile Bay, April 6, Lieutenant Heald proceeded under instructions to the Chandeleur Islands to fill in certain details of hydrography to the eastward of those islands and in Chandeleur Sound. This work was finished April 29, at which date Lieutenant Heald left for the coast of Florida to make a hydrographic survey, of which mention has been made under the heading of Section VI.

The following named officers were attached to the Bache: Ensigns T. D. Griffin, J. M. Orchard, A. Jeffries, W. C. Canfield, and J. E. Craven, U. S. N.

Statistics of the work are as follows:

| | |
|---|---|
| Miles run in sounding | 848 |
| Angles measured | 2,371 |
| Number of soundings | 20,283 |

*Determination of the longitudes of Little Rock, Texarkana, and Fort Smith, Ark.*—In March, 1885, instructions were issued, organizing three longitude parties for the ensuing season, two of these parties for the determination of primary stations and one for secondary.

Assistant Edwin Smith was placed in general charge of the work; Assistant C. H. Sinclair was assigned to the charge of the subparty for primary determinations, and Subassistant E. D. Preston was detailed in charge of the subparty at secondary stations.

The plan of operations included the determination of three stations in Arkansas, one of them Little Rock, a primary station, and two others, Texarkana and Fort Smith, secondary. At Fort Smith and Texarkana observations were to be made for latitude also.

By the middle of April Mr. Smith was at Galveston, Tex., the initial point from which Little Rock was to be determined. At the latter station Assistant Sinclair established a temporary observatory. Continuous bad weather for upwards of ten days delayed the beginning of the work. Exchanges of telegraphic signals were obtained on the nights of April 28 and 30, May 3, 4, 6, and 9, but of these the nights of April 28 and May 4 were imperfect. The observers then changed places, and, Mr. Smith being at Little Rock and Mr. Sinclair at Galveston, the longitude determination was completed by exchanges obtained on the nights of May 12, 14, 15, and 21.

The next determinations made were those of Kansas City, Mo., and Texarkana, on the boundary line between the States of Texas and Arkansas. That of Kansas City will be referred to under the heading of Section XV. For the longitude of Texarkana signals were exchanged between Assistant Smith at Little Rock and Subassistant Preston at Texarkana. This being a secondary station, the observers did not change places. Longitude signals were successfully exchanged on the nights of May 30, 31, June 1 and 2. Mr. Preston determined the latitude of his station, connected its position with that of the ninety-eighth mile-stone north of the Sabine River on the boundary line between Texas and Arkansas, and established a meridian line for the city engineer.

He then proceeded to Fort Smith, Ark., from which point he exchanged longitude signals with the observer at Little Rock, Mr. Sinclair, who had exchanged stations with Mr. Smith. The exchanges of signals for longitude between Messrs. Smith and Sinclair will be referred to under the heading of Section XV. With Little Rock exchanges of longitude signals were obtained on the nights of June 12, 18, 19, and 20. Mr. Preston determined the latitude of his astronomical station, and connected it in position with the stone monument which marks the line between the State of Arkansas and the Choctaw Nation (Indian Territory). This monument is called "Initial Point," and all miles on the State line count north and south from it. A meridian line was also established for the City Engineer.

Upon the completion of work at Fort Smith, Mr. Preston proceeded under instructions to

Kansas City, Mo., in order to observe for personal equation with Messrs. Smith and Sinclair. Further mention of this work will be made under the heading of Section XV.

*Triangulation and topography of the coast of Louisiana from Coté Blanche Bay to the westward.*—In February, 1885, Assistant F. W. Perkins was instructed to proceed to New Orleans and fit out the steamer Hitchcock for the purpose of continuing the triangulation and topography of the coast of Louisiana from Coté Blanche Bay to the westward. It had been supposed that some points of the old triangulation, executed previous to 1861, might be found, but this proved to be not the case. Owing to the very soft and yielding nature of the marshy shores of the bay, all of the old marks had disappeared.

A base line about two and one-eighth miles in length, was accordingly measured near the Southwest Pass of Vermillion Bay, and from this a new triangulation was made to establish points for the topography. It was only by the greatest care that moderately good results could be obtained. The local term "floating turf" well describes the unstable nature of the marshy shores. They are subject to constant change, and the preservation of the station marks is thereby rendered doubtful.

Field operations were closed May 20, at which date the following statistics of the work are reported:

| | |
|---|---|
| Area covered in square miles by triangulation | 400 |
| Number of stations occupied | 16 |
| Number of positions determined | 31 |
| Miles of shore line of topography run | 30 |
| Area of topography in square miles | 24 |

Mr. Perkins speaks in terms of high praise of the untiring efforts of Mr. E. L. Taney, who served as aid in the party, and Mr. Richard C. Wilson, of Mobile, who volunteered to do duty as cadet-engineer and clerk, serving without pay. He expressed his many obligations to Mr. Avery, the proprietor of Petit Anse Island, and to Major Crooks, the superintendent of the salt-works there, for their courtesy and the material assistance rendered by them to the work. Also to Messrs. Netlie and Kock, of the Morgan steamship line, for facilities kindly offered in securing the Hitchcock for the summer.

Other duty assigned to Mr. Perkins has been referred to under the headings of Sections I and II. In the latter part of the summer and early in the autumn of 1884, he was engaged in some experiments for the improvement of the lights used as night-signals in geodetic work. These experiments were so far successful as to increase the available amount of light-rays from about twenty-five to two hundred candle-power. This was accomplished by a simple arrangement of reflectors which did not involve any material increase in the amount of combustion. With more time at his command, Mr. Perkins hopes to present a form of apparatus wholly satisfactory and practical. He expresses his indebtedness to Joseph Funck, foreman of the lamp shop of the Light-House Establishment, who, by permission of General Duane, Engineer of the Third Light-house District, rendered essential aid in conducting the photometrical observations and arranging details of construction.

*Hydrographic survey off the coast of Louisiana from Sabine Pass eastward.*—In continuation of the hydrography of the coast of Louisiana from Sabine Pass eastward, Lieut. F. H. Crosby, U. S. N., Assistant Coast and Geodetic Survey, was instructed, in December, 1884, to complete the fitting of the steamer Gedney for sea, and proceed at as early a date as practicable to Sabine Pass.

Upon reaching that locality at the beginning of March, Lieutenant Crosby established his principal tide-gauge for the season on Dorman's wharf at Sabine Pass. This gauge, a simple staff nailed to the wharf piling, its numbers increasing with rise of tide, was observed continuously from March 10 to June 5. A second gauge was located at the mouth of the Calcasieu River, and observed during three days. Owing to the freshets in the river during the spring season it was found impossible to establish a plane of reference by observation, but through the courtesy of the United States Army engineers engaged in constructing jetties on the bar at Sabine Pass, Lieutenant Crosby was enabled to get a comparison with their self-registering gauge at that locality.

This gauge is referred to a plane of reference depending upon continuous observations for six years.

Lieutenant Crosby observes that the work of the season showed a continuation to the eastward as far as Calcasieu River of the outlying shoal developed during the previous year by Lieut. G. C. Hanus, U. S. N., Assistant. The portion developed in 1885 was found to be irregular in form and lumpy, with a least depth of nineteen feet. The bottom is of sand and shells and in perfectly smooth water may be seen distinctly to a depth of six fathoms.

Outside of this shoal, and about thirty miles off shore, was found a ridge formed of broken shells, the eastern end bearing south one-quarter west from Calcasieu light, and having on it a least depth of five fathoms and three and a half feet bearing south (magnetic) from Calcasieu light. Outside, inside, and between these shoals the bottom is of blue mud, mixed in some places with broken shells. On both sides of the shoals the water deepens rapidly.

Each of the rivers or passes, Sabine, Calcasieu, and Mermentau, emptying into the Gulf on this portion of the coast, has an enlargement or lake at a few miles inland, forming a tidal reservoir, and causing very strong tidal currents between the lakes and the Gulf. Each is obstructed by a bar at its mouth. Over the bars at Sabine and Calcasieu but six feet of water can be carried at low tide, and over the Mermentau bar but four feet.

With regard to the current in this part of the Gulf, Lieutenant Crosby remarks that they are governed by the direction of the wind, and that in calm weather there is a set of from one-half to one knot to the westward.

Lieutenant Crosby had the aid of the following named officers: Ensigns T. M Brumby, A. L. Hall, J. H. Hetherington, and J. S. Watters, U. S. N.

The statistics of the season. which closed June 5, are as follows:

| | |
|---|---|
| Miles run in sounding | 1,405 |
| Angles measured | 5,100 |
| Number of soundings | 53,052 |

## SECTION IX.

### TEXAS AND INDIAN TERRITORY, INCLUDING GULF COAST, BAYS, AND RIVERS.

(SKETCHES Nos. 1, 9, 17, and 18.)

*Determination of the longitude of Brownsville, Tex.*—Reference has been made, under the heading of the previous section, to the occupation of the longitude station at Galveston, Tex., by Assistant Edwin Smith as an initial point for the determination of the longitude of certain primary and secondary points in Texas and Arkansas. The plan of work included the determination of Brownsville, Tex., in latitude and longitude. The station at Brownsville was established by Sub-assistant E. D. Preston, and after many delays, owing to unfavorable weather, difficulties of transportation, and accidents to the lines, an exchange of telegraphic signals for longitude was obtained with Mr. Smith at Galveston, May 6. Stormy weather prevailed for nearly a week after this date; during this interval Assistant Sinclair took Assistant Smith's place at Galveston, and additional exchanges were obtained on the nights of May 12, 13, and 14. The latitude of the Brownsville station was determined, and the position of the transit connected with that of the geodetic station which had been recently established by Assistant Halter in the garrison, near the artillery barracks. A meridian line was laid out at the request of the county surveyor.

An account of the work subsequently executed by Mr. Preston while connected with the longitude party is given under the heading of Section VIII, and a further notice of the operations of this party under the heading of Section XV.

*Triangulation and wire measurement between Point Isabel and Brownsville, Tex.*—The connection of a station in the town of Brownsville, Tex., with the triangulation of the Gulf coast was accomplished in the winter and spring of 1885, by Assistant R. E. Halter. Starting from a point near the mouth of the Rio Grande in January, the triangulation was carried up the river a distance of about ten and a half miles, and thence by a wire measurement combined with measurements of angles at fixed points along the line to Brownsville. Field operations were closed April 15, and under instructions Mr. Halter sent his instruments and camp equipage to New Orleans for storage and reported at the office in Washington.

The statistics are:

| | |
|---|---|
| Number of stations occupied | 12 |
| Number of observations | 1,070 |
| Length in meters of wire measurement | 18,976 |

## SECTION X.

### CALIFORNIA, INCLUDING THE COAST, BAYS, HARBORS, AND RIVERS.

(SKETCHES Nos. 2, 9, 10, 11, 16, 17, and 18.)

*Survey of the coast line connecting the work at San Juan Capistrano with that at Newport Bay, California.*—At the beginning of the fiscal year, Assistant A. F. Rodgers had organized his party, in pursuance of instructions, and was engaged in the work of completing the coast-line survey between San Juan Capistrano and Newport Bay, California. Between July 1 and 15 three of the points of the triangulation of 1875 in the vicinity of Newport Bay were recovered; the necessary signals, twenty-eight in number, to continue the coast triangulation to San Juan Capistrano were then erected, and a general reconnaissance was made from that vicinity southward to San Diego Bay.

On July 15 Mr. Rodgers proceeded to San Francisco to purchase an outfit of tents for his party, and to attend to certain office work that was needed. He made and forwarded to the office a tracing of the shore-line survey from San Juan Capistrano southward to San Mateo Point. On August 7 he left San Francisco for the south coast, and moved his party to Laguna Cañon. Sub-assistant Isaac Winston reported for duty in the party August 14. During August and September observations of horizontal angles were prosecuted, and early in October the field computations were sufficiently advanced to furnish data for the projection of a topographical sheet to cover the survey of the shore line included in the triangulation. This topographic survey was prosecuted till November 1, when the exhaustion of the appropriation compelled the suspension of field operations.

Mr. Rodgers acknowledges the courtesy of Hon. Richard Egan, of San Juan Capistrano, in giving the use of an adobe building, comparatively fire proof, for the storage of the instruments at the close of the season, free of charge. He commends also the efficient and ever-ready service of Mr. Winston, who remained with the party until its arrival in San Francisco, when he was detached and ordered to duty at Los Angeles.

During the remainder of the fiscal year Assistant Rodgers was engaged on office work at San Francisco. On December 26, at the request of Assistant Davidson, who had been ordered to Washington, he took charge of the suboffice at San Francisco, and continued on that duty till Mr. Davidson's return in April. At the close of the fiscal year he had made all arrangements to take the field in accordance with instructions, and left San Francisco, by the south coast steamer, June 30.

The statistics of the season of 1884 are:

| | |
|---|---|
| Number of stations occupied | 35 |
| Number of stations and objects observed on | 45 |
| Number of horizontal directions determined | 834 |
| Number of horizontal angles measured | 4,990 |
| Number of pointings made | 10,814 |
| Number of geographical positions determined | 34 |

*Series of observations continued at the magnetic self-registering record station at Los Angeles, Cal.*—Since October, 1882, an almost unbroken series of absolute and differential magnetic observations has been maintained at the Magnetic Observatory at Los Angeles, Cal. At the beginning of the fiscal year 1884-'85, Assistant Marcus Baker, who had begun this series of observations, was still in charge of them, but with instructions for his relief from that duty and recall to Washington. Mr. Carlisle Terry, Aid in the Survey, had been directed to report to Mr. Baker in order to learn the methods of observation and qualify himself to take charge of the observatory. On the 1st of August, 1884, Mr. Baker proceeded to Washington, by way of Toronto, Canada, under instructions for special duty and for conference with the Superintendent respecting magnetic work. Reference is made under the headings of Section II and special operations, to duty assigned to Mr. Baker on the Atlantic coast.

Mr. Terry has submitted a full report of his work during the eleven months ending with June, 1885. The photographic records of the elements of the relative magnetic declination, dip, and intensity, with the Adie magnetographs were made as nearly continuous as possible. During three days near the middle of each month observations were made to determine the absolute declination, dip, and horizontal intensity, and from these absolute vertical force and total intensity were deduced.

Time was determined once a month by observations of the sun.

On September 7 and November 30 the vertical force magnet was rebalanced, and on the same dates, and also on December 4, its scale values were redetermined. The unifilar, bifilar, and vertical force scales were read each day before and after changing the photographic papers; readings were taken also of the maximum and minimum thermometers each day at 8 a. m. and 5. p. m. Hourly readings of the unifilar, bifilar, and vertical force traces were made, and hourly, daily, and monthly means for each month deduced.

At the time Mr. Terry took charge of the observatory much difficulty had been experienced in obtaining photographic traces of sufficient distinctness, but by using the greatest care he was able to procure a record. In November, 1884, by making some slight changes in the sensitizing process, and by the use of new trays, some improvement was secured, and on the 1st of June, 1885, gelatino-bromide paper was substituted for the bromo-iodide of silver paper previously in use. The gelatino-bromide paper, Mr. Terry reports as having the advantage of reducing the amount of labor needed to procure a record, and as far more uniform and continuous in its results.

Mr. Terry had the assistance of Subassistant Isaac Winston from November 15, 1884, to April 30, 1885, and of Mr. A. L. DuPuy from May 10 to the close of the fiscal year.

A summary of the year's statistics is as follows:

| | |
|---|---|
| Number of absolute measures | 5, 280 |
| Number of relative measures | 6, 012 |
| Number of readings of photographic traces | 42, 610 |

The records, computations, and abstracts of results to the close of the fiscal year have been transmitted to the office.

*Continuation of the primary triangulation of the coast of California north of Point Concepcion.*—Field operations in continuation of the primary triangulation of the California coast north of Point Concepcion were resumed by Assistant James S. Lawson in November, 1884, the condition of the atmosphere not being favorable for work at an earlier period in the fiscal year. The station selected for occupation was Rocky Butte, a primary point of three thousand four hundred feet elevation, about six miles from the coast.

Knowing the violence of the winter gales, Mr. Lawson deemed it advisable to erect a temporary wooden observatory for the shelter of the instruments, instead of using tents, and the advantage of so doing was proved by experience, one of the heavy rain storms accompanied by high winds having lasted ten days.

The work at Rocky Butte consisted of horizontal and vertical measures, and observations for time and latitude. For horizontal direction observations were made upon thirteen objects, six of which were heliotropes at primary stations, one the light-house at Piedras Blancas, one a station at Hollister Peak, and five poles, four of which belonged to the tertiary coast triangulation.

The theodolite was used in twenty-three positions; and at all of the pointings on the principal stations, readings of the ocular micrometer were taken. On all prominent mountain peaks and objects within the horizon of the station pointings were made. For elevation, measurements of double zenith distances were made on six main stations and on ten other objects.

For time, observations were made on six nights, and for the latitude of the station twenty-nine pairs of stars were observed on seven nights. The instruments used in the several classes of observations were the twelve-inch theodolite No. 131, the eight-inch vertical circle No. 57, and the meridian instrument No. 16.

Work at Rocky Butte was closed January 31, 1885, and the camp was at once moved to the vicinity of Castle Mountain, with the intention of occupying that station, but it was found that the appropriation was too far exhausted to permit any other course than to disband the party and store the camp equipage till next season.

Mr. Lawson reports the following statistics of the work:

| | |
|---|---|
| Number of observations for horizontal direction | 1,002 |
| Number of observations for vertical measures | 762 |
| Number of observations for latitude | 212 |
| Number of observations for time | 58 |

On returning to San Francisco a determination of the value of the micrometer of the meridian instrument was made at the astronomical station in Lafayette Park, the sets obtained at Rocky Butte having been much broken by clouds.

In all of the operations of the party Mr. Lawson had the assistance of Mr. P. A. Welker, Aid, and speaks highly of the value of his services. During the remainder of the fiscal year Mr. Lawson was engaged in office work, and towards its close received instructions to prepare for taking the field. The records and computations of his observations at Rocky Butte were completed and sent to the office.

*Survey of the coast of California continued from Moro Bay westward.*—At the beginning of the fiscal year Assistant Stehman Forney had received instructions to continue the tertiary triangulation of the coast of California and the shore-line topography from Moro Bay westward. At the close of the season, which was a short one, on account of the smallness of the appropriation, Mr. Forney had carried his survey to the line Irving-Estrada, within three miles of the town of Cambria, San Luis Obispo County. By the end of October the shore line and topography of two full plane-table sheets were completed, and the shore line on a third sheet for a distance of six miles. Every opportunity was taken advantage of to connect the tertiary points with the primary triangulation.

Statistics of the season are:

| | |
|---|---|
| Number of stations occupied | 2 |
| Number of signals observed upon | 11 |
| Number of angles measured | 480 |
| Miles of shore line surveyed | 8 |
| Miles of creeks | 17 |
| Miles of roads, telegraph, and fences | 78 |
| Area surveyed in square miles | 18 |

*Hydrographic survey of the California coast in the vicinity of San Simeon.*—As mentioned in the last annual report, the hydrographic party under charge of Lieut. E. D. Taussig, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer McArthur, was near San Simeon, Cal., at the beginning of the fiscal year, engaged in hydrographic work off that part of the coast. The limits of Lieutenant Taussig's survey, which began June 3 and ended July 16, 1884, were from Pecho Point, near San Luis Obispo Bay, to a point beyond Cayucos in Estero Bay.

Some extracts from Lieutenant Taussig's report, relating to the hydrographic characteristics of the coast will be of interest:

"The harbor of San Simeon, in the northeastern part of San Simeon Bay is a good summer anchorage. Vessels approaching from the southward can work up the bay without danger as long as they keep clear of the kelp, which generally lines the shores within the three-fathom line. Off the peninsula, which forms the western side of the harbor of San Simeon, is a reef lined with kelp, on which the sea generally breaks. This reef extends in thick kelp for a distance of three-sixteenths of a mile southeast of the point into six fathoms of water, and one-eighth of a mile further to the southeast there are three small pieces of detached kelp in seven and a half fathoms of water. In order to avoid this reef, my usual course in entering San Simeon Harbor in a fog was to feel my way to the kelp on the eastern shore and then head about northwest until the anchorage was reached.

"The best anchorage for light-draught vessels is about one-eighth of a mile east of Whaler's or Clark's wharf, in three fathoms of water (at *low* low water) where there is a good lee from the northwest winds. In the winter months, the southwest swell makes this anchorage, like most of the ports on the coast, an unsafe one. If, however, obliged to ride out a gale, the same anchorage is to be preferred, as the reef and peninsula serve to break the sea somewhat.

"The shores along the coast, from the harbor of San Simeon to the northwest are low bluffs, with occasional small stretches of sand beach. The country rises into mountains about two miles from the coast. These mountains dip towards the sea, and reach the coast at the end of our work northwest of Arroyo San Juan Carpofero.

"Off the shore the coast is generally lined with kelp, and the soundings are irregular; the general character of the bottom is rocky; gray sand is found off the Castro House, and formerly schooners anchored there and lightered off their freight. Since the construction of the wharf in the harbor of San Simeon this has not been done. Patches of kelp are found in as much as thirteen fathoms of water one-half mile south by west of Castro station. One and one-eighth miles southwest one quarter south of Castro House is a rock with three and one-fourth fathoms in kelp, and irregular soundings from six to nine fathoms around it. This is the outer danger of the coast between the peninsula of San Simeon and the rocks called Piedras Blancas. Vessels bound from San Simeon northward should keep three-fourths of a mile off shore in order to keep in not less than ten fathoms of water, while patches of kelp may be found a mile off shore.

"Vessels may approach the rocks called Piedras Blancas with impunity, taking care not to approach too close on the western and northwestern sides, as the bottom is foul and rocky."

Lieutenant Taussig gives in detail other statements respecting dangers to be avoided in approaching the coast, and his report will furnish valuable material for the forthcoming new edition of the Coast Pilot of California and Oregon.

With regard to the examination of the bar of San Francisco, to which some days were devoted in June, and one day, the 18th, in July, Lieutenant Taussig remarks that while all the time occupied there was well spent, he does not think the examination complete enough to state officially that the bar has not changed. It was his impression, however, that no material changes have taken place, and that a survey will probably show slightly deeper water in the southern channel than is given by the chart, and a possible extension of the southern end of the Four-Fathom Bank. The specimens of bottom show no signs of silt, and the living animals on the crest of the bar prove that the mining débris, and the silt of the streams emptying into the bay have not yet effected a deposit.

Lieutenant Taussig expresses his obligations to Assistant Forney for valuable information and services in connection with the work in the neighborhood of Cayucos, and to Assistant Davidson for information relating to the San Francisco Bar, and other data of value. The efficient aid afforded by the officers attached to the party is acknowledged: Lieut. F. H. Lefavor, and Ensigns W. L. Burdick, P. B. Bibb, and J. L. Purcell, U. S. N.

The statistics of the hydrography are:

| | |
|---|---|
| Miles run in sounding | 1,069 |
| Angles measured | 5,221 |
| Number of soundings | 30,057 |

On the 1st of October Lieutenant Taussig was instructed to resume the hydrographic survey of the northern coast of California. An account of this work, and of that subsequently executed by his party under instructions dated in February, 1885, will be given under a later heading in this section.

***Occupation of stations in continuation of the primary triangulation of the coast of California.***—In July and during part of August, 1884, Assistant George Davidson was in Washington, having been called there for conference with the Superintendent, but he continued to direct the main triangulation and astronomical work on the coast of California, the Saucelito and Alaska tidal parties, the Coast Pilot work, and other operations, reference to which will be made here. Upon returning to the Pacific coast towards the close of August, Mr. Davidson was instructed to proceed by way of the Atlantic and Pacific Railroad, following the thirty-fifth parallel, in order to study the features of that region with reference to its availability for geodetic work, for magnetic observations, &c. In December, 1884, he was again ordered to Washington for conference with the Superintendent, and in March, 1885, returned to San Francisco.

In the month of April following Mr. Davidson was placed, by special instructions, in charge of the operations of the survey on the Pacific coast, the hydrographic work and the magnetic work at Los Angeles excepted. He was to submit to the Superintendent a systematic programme of work for Sections X, XI, and XII, indicating assignments that would be advisable, giving detailed instructions to officers in charge of parties, and supervising generally their operations. He was to take charge of the suboffice at San Francisco, and regulate all details connected with it.

During his absence in the summer of 1884 the work of copying and computing the triangulation, astronomical, and magnetic observations of the previous season was completed, and as soon as a prospect of fair weather for field work appeared, Mr. Davidson's party occupied Mount Diablo, a station of the main chain in Contra Costa County. At Mount Diablo horizontal and vertical angles and magnetic declination were observed. The instruments used were the twenty-inch theodolite No. 115, vertical circle No. 80, and magnetometer No. 3. Extremely boisterous weather prevailed and long storms retarded the work.

Mr. Davidson remarks that at this station the experience of the party in the previous triangulation work was verified with regard to the better showing of the heliotropes in the winter months as compared with the summer, but the drawbacks in rainy seasons are very great when the party has to move to different stations or is encamped at an exposed station.

By the end of December all of the observations required at Mount Diablo had been obtained, and preparations were begun for moving camp to Toro Mountain, a station of the primary coast triangulation, about ninety-five miles in a southwesterly direction from Diablo. Observations at Toro were begun January 20. The same character of work was done as at Diablo, with the addition of observations for time, latitude, and azimuth. Field work at Toro was closed, and the party discharged February 13.

Assistant Davidson expresses his hearty commendation of the prompt, cheerful, and energetic execution of all duty intrusted to them by Subassistant R. A. Marr, and Aid Fremont Morse, attached to his party. Mr. Marr made the observations for horizontal directions and azimuth; Mr. Morse those for vertical angles, time, latitude, and the magnetic elements. At Mount Toro Mr. C. B. Hill, acting aid, assisted in the observations and in recording.

At Diablo observations were taken on the north dome of the Lick Observatory, at Mount Hamilton, to check the observations of the previous seasons.

The statistics of work at Diablo and Toro are as follows:

| | |
|---|---|
| At Diablo: | |
| Series of observations for horizontal direction | 82 |
| Number of observations of horizontal direction | 344 |
| Number of ocular micrometer pointings | 1,350 |
| Number of observations of vertical angles (eight stations observed) | 178 |
| At Toro: | |
| Series of observations for horizontal direction | 89 |
| Number of observations of horizontal direction | 327 |
| Number of ocular micrometer pointings | 1,300 |
| Number of observations of vertical angles (twelve stations observed) | 158 |

In April, 1885, Mr. Marr was relieved from duty in Mr. Davidson's party and ordered to the steamer Patterson.

Towards the close of the fiscal year, there being a small amount of the allotment available, Mr. Morse was directed to occupy the two triangulation stations, Rocky Mound and Red Hill, overlooking the bay of San Francisco, the object being to make the most direct connection with the triangulation depending on the Yolo base. For this work the ten-inch Gambey repeating theodolite was used, and the vertical angles were connected with Red Hill station, to which

Assistant Cutts had formerly run a line of levels from San Francisco Bay. Mr. Morse has furnished the following statistics of work at the two stations:

| | |
|---|---|
| Number of horizontal angles measured | 8 |
| Number of observations for horizontal angles | 744 |
| Number of vertical angles measured | 6 |
| Number of observations of vertical angles | 153 |

A determination of the geographical position of the Yaquina Light House, on the coast of Oregon, having become desirable, Mr. Morse was instructed to proceed thither, and fix the latitude and longitude of a station which could be connected with the old tertiary triangulation and with the light house. He succeeded in obtaining thirty-one observations on twenty-four pairs of stars, on three nights, with the Davidson meridian instrument No. 1, and also observed one lunar transit for longitude. The correction to the latitude of the Light House was 55″, nearly one mile.

*Coast Pilot work.*—With regard to the Coast Pilot work, involving the preparation for publication of a new edition of the Coast Pilot of California, Oregon, and Washington Territory, Mr. Davidson reports that F. Westdahl, draughtsman, in addition to other duties, finished the series of views which he had taken at sea during the previous season. These include many of the headlands between San Diego and San Francisco. In December Mr. Davidson himself made a trip to fill in views not obtained before. In May and June Mr. Westdahl made a trip to the northward as far as Puget Sound to obtain views, with fair success, despite unfavorable weather.

On account of the large accumulation of material from surveys made since the last edition of the work was published, the labor on details has been very great.

*Magnetic observations.*—As the time of the maximum of easterly magnetic declination is rapidly approaching the part of the coast in the vicinity of San Francisco, Mr. Davidson kept up observations for declination and intensity at the old astronomical station at the Presidio of San Francisco. Observations for declination were made by himself and by Messrs. Marr and Morse on seven days, and referred to the station, Mount Tamalpais east; also observations for total intensity, &c.

*Longitude of a station of the Hawaiian Government survey.*—At the request of Prof. W. D. Alexander, chief of the Hawaiian Government survey, who was anxious to connect one of his stations with a station of the Coast and Geodetic Survey for difference of longitude, Mr. Davidson undertook to obtain time, and compare with Professor Alexander's chronometers sent to San Francisco by each steamer. But the whole of the work of observing, comparing, and reducing was done by Mr. Charles B. Hill, mostly outside of official hours.

*San Francisco suboffice.*—In the suboffice at San Francisco, under the immediate charge of Assistant Davidson, Mr. Ferdinand Westdahl served faithfully throughout the year as draughtsman, and, as already mentioned, was part of the time on detached duty. Mr. C. B. Hill served acceptably as clerk, and when required took part in field work. Vicente Denis, as janitor, had care of the camp outfit, &c., of the field parties, and did his work well, without regard to hours.

*Field catalogue of time and circumpolar stars.*—Outside of his official duties, Mr. Davidson continued work upon his field catalogue of time and circumpolar stars (Appendix No. 18, Report for 1883), so as to enlarge it for a future edition.

*Rocks in Mission Bay.*—Conflicting reports having arisen in regard to the position of certain rocks in the channel off Point of Rocks, Mission Bay, San Francisco, Mr. Davidson caused a thorough examination to be made of the locality, and established the fact of the existence of two separate rocks, a north rock and a south rock. Upon Mr. Davidson's recommendation, a buoy was placed on the south rock also, it being abreast of two of the largest and busiest wharves of the whole city front. Upon the chart of San Francisco entrance, edition of 1884, both rocks are shown, the north one as Mission Bay Rock, the south one as Sonoma Rock.

*The bar of San Francisco.*—An elaborate report has been submitted by Mr. Davidson upon the bar of San Francisco, with special reference to changes reported to have taken place in it. Tracings accompany the report, showing the lines of the six and ten fathom curves according to the surveys of 1855 and 1873; also a tracing of several cross-sections of the bar. Mr. Davidson's conclusions are decidedly adverse to the supposition that any changes of moment have occurred. Some extracts from his transmitting letter will be of interest.

"It has been asserted recently that the south channel had been abandoned on account of the shoaling. This statement is directly contrary to the fact. On the afternoon of the day the statement was published, I saw a deeply laden British bark crossing by the western edge of the south channel when the bar was very rough, almost breaking all round."

"It has been asserted that great deposits have taken place inside the bar within the ten-fathom line; the statement is contrary to the fact. It is relied upon as necessarily proving deposition of material, that the muddy waters of the Sacramento River deposit their material on the bar, &c. In a certain degree, this action of deposition is inevitable, but it will first take place in more favorable situations than on the bar. I have shown, many years since, that the deeply discolored waters of the Sacramento and other rivers were carried north of Point Reyes."

"I wish to repeat former recommendations which I have made on the subject: that every ten years a minute resurvey of the bar and immediate approaches should be made to *study the law of change, if there be any.* With this survey there should be such an examination of the material of the bar as would establish the source of the supply. I believe that it is mainly due the coast eddy current from the southern shore line."

*Self-registering tide-gauge record kept up at Saucelito, San Francisco Bay.*—Assistant Davidson reports that the work at this station, which is carried on under his supervision by Mr. E. Gray, has been of uniformly good character and without break in the record during the year. The tabulations and the original sheets have been regularly forwarded to the office. Observations for time and comparisons of chronometers were made when required by Mr. C. B. Hill. During the year the pier was in some danger, because the *terèdo* had destroyed nearly all the bracing of the piles and the protection against heavy swells. The repairs necessary were made.

Reference to the work of the Alaska tidal party, also under Mr. Davidson's general supervision, will be found under the heading of Section XII.

*Hydrographic surveys on the California coast in Humboldt Bay and between Brushy Point and White Rock.*—In pursuance of instructions for the execution of hydrographic work on the north coast of California, Lieut. E. D. Taussig, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer McArthur, left San Francisco, October 18, 1884, bound for Humboldt Bay. An examination of this bay and its approaches was made a secondary object, to be accomplished when work outside off Cape Mendocino was found impracticable, but every attempt made by Lieutenant Taussig to do off-shore work was frustrated by bad weather, so that ultimately he was compelled to confine his survey to the waters of Humboldt Bay. The months of November and December, which are generally favorable, proved particularly stormy in 1884.

The survey of Humboldt Bar was made in the large life boat of the life saving station. The bar, especially during the winter months, is generally rough. Vessels are detained not unfrequently for many days in going out, and sometimes in coming in.

With regard to the channel, Lieutenant Taussig found that since last October it had been to the southward of the middle ground, and for eighteen months before that time to the northward, changing so frequently, however, that no chart can be of any aid to a stranger crossing the bar. The positions of the buoys on the bar and in the channels are often changed by the pilot tugs, but not as often as the channels change, and the buoys must not be accepted, therefore, as guides by strangers.

To obtain a plane of reference for the soundings, a tide-gauge was established at Field's Landing.

Lieutenant Taussig expresses his special indebtedness to Ensign J. N. Jordan, U. S. N., for unflagging zeal and attention to duty. Ensigns W. L. Burdick and F. A. McNutt, U. S. N., were also attached to the party, and rendered acceptable service.

Statistics of work in Humboldt Bay are:

| | |
|---|---|
| Miles run in sounding | 166 |
| Angles measured | 936 |
| Number of soundings | 7,020 |

Early in December the McArthur returned to San Francisco, and was taken to the Mare Island navy-yard for repairs. On the 8th of April, 1885, all preparations having been completed for work on the north coast, Lieutenant Taussig and his party left San Francisco for Brushy Point, and anchored off that point the next day. He was provided with two hydrographic sheets, each on a scale of 1–20000; the first with limits from Brushy Point to Ussal Rock, the second from Ussal Rock to White Rock.

Lieutenant Taussig observes that the general hydrographic features of this part of the coast are in the main similar to those of the coast immediately to the southward. The land is bolder, the coast range comes close to the ocean, and at times so close as to rise almost vertically from the sea. Here and there a flat has induced a settler to start a cattle ranch.

The anchorages along this section are not to be recommended. None of them have any lee. A few projecting rocks, with a more or less fancied freedom from undertow, or affording some slight protection from the full strength of the wind have induced some persons to build chutes from Brushy Point, Kibessilah, Westport, Cottaneva, and Bear Harbor, and when the roads are passable, and the southeast gales not too frequent, these chutes do a lively business in shipping bark and redwood lumber.

The projecting headlands at Cottaneva, Big White Rock, Bear Harbor, Shelter Cove, and Point Gorda break the force of the sea in the strong northwesters that prevail during the summer months. The small coasting steamers take advantage of this in running up the coast. Strangers, however, unfamiliar with the coast and the soundings near it, should not approach it, between Brushy Point and Ussal Rock, nearer than half a mile without great caution. The dangers are as a rule in sight, but the uneven and rocky character of the bottom and the peculiar form of some of the sunken rocks makes it very probable that a number are as yet uncharted.

With the above general statement, Lieutenant Taussig presents in his report full details respecting the several localities included in his survey. To obtain planes of reference for his soundings, he established a tide-gauge at one of the rocks near the south chute at Westport. At this point tides were observed from April 12 to June 12, inclusive. Tidal observations were made also at Little River for two days to connect with the tide-level at Westport, and also to reduce the supplementary soundings taken in Little River to define the line of reef, and to locate a pinnacle rock (heretofore unknown) in the northwestern part of the harbor.

The following named officers served on board the McArthur during this work: Ensign J. N. Jordan, U. S. N., till his detachment May 31, and Ensigns W. L. Burdick, J. A. Bell, and F. A. McNutt, U. S. N.

Statistics of the season are:

| | |
|---|---|
| Miles run in sounding | 1, 417 |
| Angles measured | 3, 920 |
| Number of soundings | 23, 979 |
| Number of specimens of bottom preserved | 40 |

About the middle of June the McArthur returned to San Francisco.

## SECTION XI.

### OREGON AND WASHINGTON TERRITORY, INCLUDING COAST, INTERIOR BAYS, PORTS, AND RIVERS.

(SKETCHES Nos. 2, 11, 12, 17, and 18.)

*Triangulation and topography of the Umpquah River, Oregon.*—In continuation of the survey of the Umpquah River and of the adjacent coast, Assistant Louis A. Sentgeller took the field, under instructions, at as early a period in the spring of 1885 as the allotment for his work would permit. Having organized his party towards the end of April, he established his camp on the Umpquah early in May, and proceeded at once to recover and readjust the triangulation stations of preceding seasons, re-establishing two stations which had been destroyed. The season proving to be favorable, the triangulation north of the Umpquah was resumed and devoloped so far as necessary to insure a permanent base or bases for future requirements in carrying the work northward.

The selection of stations was attended with difficulty, owing to the formation of the country;

abrupt and high sand hills, timbered close to the coast line. Observations of horizontal angles were begun May 12 and continued till June 14, at which date complete connections had been established to the northward, and sufficient results obtained to furnish the points necessary for the topography and hydrography of the Umpquah River.

On June 16 the entire party was transferred to the beach between Umpquah River and Coos Bay, with a view of effecting a junction with the triangulation which had been executed in that locality by Assistant James S. Lawson. A temporary camp having been established at Ten-Mile Creek, about half way between the two entrances, a reconnaissance was developed from the creek, both northward and southward, while at the same time observations of horizontal angles were made to follow up the reconnaissance as it advanced from the Umpquah.

Towards the end of June Mr. Sengeteller proceeded with his party to Empire City, Coos Bay, and in that vicinity recovered two stations of the former triangulation, the line joining which served as a base for the desired connection. Until June 30 the reconnaissance and erection of stations southward from the recovered line "Pony-Simpson" was continued, a complete junction being effected, leaving two stations to be erected, and, if possible, one of former work to be recovered.

South of Umpquah River and toward Coos Bay the character of country was found to be similar to that already alluded to north of Umpquah entrance, namely, a low sand beach, backed for about half a mile by bare sand dunes of all imaginable shapes, gradually increasing in height as they recede from the coast until about one mile from it, when defined ridges and hills appear, the latter reaching an average elevation of about two hundred feet. These are backed by densely timbered ridges and hills of greater elevation, interspersed with many lakes and ravines and practically impenetrable. But occasional glimpses of the mountains in the interior can be obtained. At the mouth of Ten-Mile Creek but a very small part of the Umpquah hills can be seen, and this from points less than half a mile apart.

Mr. C. W. Fitzgerald served acceptably as recorder of the party.

Statistics of the season to the close of the fiscal year are as follows:

| | |
|---|---|
| Number of stations determined | 15 |
| Number of stations occupied | 19 |
| Number of angles measured | 201 |
| Number of observations made | 4,072 |

As this survey is in active progress at the date at which this report closes, further mention of it will be made in the next annual report.

*Continuation of the topographical survey of the Columbia and Willamette Rivers. Hydrography of the Willamette River.*—Mention was made in the last annual report of the progress made by Assistant Cleveland Rockwell, at the end of June, 1884, in the topographical survey of the Columbia and Willamette Rivers. As there stated, the steady rise of the waters in these rivers, owing to the annual freshet, compelled Mr. Rockwell to move up the Willamette in his vessel, the Kincheloe, till opposite Saint John, in order to find work on the highlands forming part of the shores of that river. During the highest water he prosecuted the survey around the cities of Portland, East Portland, and Albina. Later in the season he went back again down the Columbia as far as Willow Bar. The representation of the shores of the river was limited to about a mile back from the water's edge on either side, Mr. Rockwell deeming this a sufficient border of topography to meet the needs of the work, the funds for which were limited. In the cities of Portland, East Portland, and Albina a sufficient number of the principal streets were determined to enable a plot of the city surveyor's map to be reduced to the 1-10000 scale of the topographic sheet. On the Portland or west side of the Willamette the survey was continued to include the summits of the first range of hills back of the city.

The season's work is included in two topographic sheets, one on a scale of 1-20000, which joins the topographical work previously done by Mr. Rockwell from Willow Bar up the Columbia to a point a mile above the mouth of the Willamette, and up that river to the head of Swan Island, and the other, on a scale of 1-10000, embracing the city of Portland, extends from the head of Swan Island to the south limit of that city.

Field operations were closed October 10, and the Kincheloe laid up at Albina in care of a ship-keeper.

Following are the statistics of the survey:

| | |
|---|---|
| Miles of shore line of rivers surveyed | 62 |
| Miles of shore line of ponds, creeks, and sloughs | 128 |
| Miles of railroad and all other roads | 134 |
| Area of survey in square miles | 43 |

Towards the end of the fiscal year, Mr. Rockwell was instructed to organize his party for the hydrographic survey of the Columbia River, and at the date at which this report closes was actively engaged in the prosecution of that work.

*Completion of the topography of Hood's Canal, Washington Territory. Reconnaissance of the Olympic Mountains.*—At the beginning of the fiscal year Assistant J. J. Gilbert, in pursuance of instructions, was in camp at Union City, near the head of Hood's Canal, engaged upon the topography of that inlet. The weather in the three months following was very favorable for field work, and the last topographical sheet of Hood's Canal was completed early in October. A trail connecting the head of the canal with Case's Inlet was run during the season in order to check the work.

In September a trip for reconnaissance was made to the Olympic Mountains, in order to learn something of their character, and to take some observations for the position of some of their principal peaks. Mr. Gilbert has submitted an elaborate report of this trip, accompanied with sketches of the horizon and tables of barometric readings and approximate heights. Mount Ellinor, the highest peak, was found to have an altitude of sixty-two hundred and seventy-two feet.

The statistics of the topographical survey are as follows:

| | |
|---|---|
| Miles of shore line surveyed | 67 |
| Miles of roads surveyed | 61 |
| Area surveyed in square miles | 40 |

During the winter Assistant Gilbert was engaged in office work, and before the close of the fiscal year had transmitted to Washington his original sheets, with tracings of the same.

*Hydrographic surveys in Hood's Canal, Washington Territory.*—As mentioned in the last annual report, a hydrographic survey was in progress at the beginning of the present fiscal year in the vicinity of Seabeck, on Hood's Canal, Washington Territory, under the direction of Ensign J. N. Jordan, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner Earnest. On July 19, 1884, in pursuance of instructions, Lieut. C. F. Forse, U. S. N., Assistant Coast and Geodetic Survey, proceeded to Seabeck and took charge of the party, relieving Ensign Jordan in command.

Upon Lieutenant Forse's arrival he found that Ensign Jordan had just finished the first hydrographic sheet, extending from Hazel Point to station Quatsap, including Dabop and Quilcine Bays; scale 1–20000. Work was at once begun on a second sheet of the same scale, extending from station Quatsap to station Cabin, and covering the upper part of Hood's Canal. Within the area covered by these sheets the water is very deep, increasing to over one hundred fathoms in places, and the shores as a rule very bold. The curve of fifty fathoms depth averages not more than half a mile from shore, and in many places is much nearer.

Lieutenant Forse states that no obstacles to navigation exist except a small ledge of rocks on the west side of Dabop Bay, which extends out at right angles with the shore line about fifteen hundred metres, (forty-nine hundred and twenty-one feet). At the mouths of the Dociwalaps, Duckabush, and Hamahama Rivers the flats extend out from the shore line in a semi-circle for over half a mile, and then the water deepens suddenly to over twenty fathoms. Quilcine, Seabeck, and Pleasant Harbors afford excellent anchorage.

A plane of reference (the mean of the lowest low waters) was determined by observing the tides day and night for a lunar month at a tide-gauge established in Seabeck Harbor, and referred to a bench-mark made by drilling a half-inch hole in the top of the rock used as station Seabeck.

The allotment of funds becoming nearly exhausted by the end of the first month of the fiscal year, Lieutenant Forse, in accordance with instructions, made arrangements for a reduced party, but was able, by urgent effort, to finish the hydrography to the limits of the Upper Hood's Canal sheet. This was accomplished by August 24. To that date the statistics are:

| | |
|---|---|
| Miles run in sounding | 424 |
| Angles measured | 2,675 |
| Number of soundings | 5,958 |

During the winter the Earnest and the steam-launch Tarrynot were laid up near Olympia, W. T. On June 6, 1885, in pursuance of instructions to proceed with hydrographic work in Hood's Canal and the waters east of Bainbridge Island, Lieutenant Forse made preparations for getting the schooner and steam-launch in readiness, and at the end of the fiscal year was about to begin the hydrography.

*Triangulation and topography of Possession Strait and Sound, Washington Territory.*—Reference was made in my last annual report to the beginning of the survey of Possession Strait and Sound, Washington Territory, by Assistant J. F. Pratt. He had organized his party, in pursuance of instructions for this survey, on board of the schooner Yukon, and by the 1st of July, 1884, had carried the triangulation from two of the main points in Admiralty Inlet to the line Muckilteo-Turkey, at the entrance of Possession Sound.

By July 18 the triangulation was sufficiently advanced to take up the topography, and both were pushed until the delta of the Snohomish River was reached, when the triangulation was suspended and all the energies of the party devoted to the topography. Instructions to close work, on account of the insufficiency of the funds available, were received before the survey of the Snohomish River could be carried to the head of steamboat navigation, at Snohomish City. The stations at which the work was suspended were marked, so that it can readily be resumed. Field operations were closed September 1.

Mr. Pratt observes that there is very little, if any, time in which there are not very strong currents in either one or the other direction in Possession Sound, the average rise and fall of the tide being about ten feet, and there being two high and two low waters daily. During midsummer there are very strong periodical northerly winds, interspersed with one or two southeasterly gales, and either of these produce, when blowing contrary to the tidal currents, tide rips, which are sometimes dangerous to the smaller boats used in the survey.

Statistics of the season are as follows:

| | |
|---|---|
| Number of stations occupied in the triangulation | 6 |
| Number of angles measured | 137 |
| Number of single measures | 4,830 |
| Number of geographical positions determined | 24 |
| Number of miles of shore line surveyed | 13 |
| Number of miles of rivers and creeks | 61 |
| Number of miles of shoals | 16 |
| Number of miles of roads and railroads | 3 |

Early in September Assistant Pratt was directed to report to Assistant B. A. Colonna for duty in his party, and to transfer to him at the same time the schooner Yukon. Details of the joint labors of these officers in the survey of the Strait of Fuca will be given under the next heading.

Towards the latter part of the fiscal year, upon being relieved from duty in Mr. Colonna's party, the schooner and her outfit were turned over to Mr. Pratt, and he was instructed to resume work in Possession Sound.

*Reconnaissance for the triangulation of the Strait of Fuca.*—At the beginning of the fiscal year Assistant B. A Colonna was actively engaged, in pursuance of instructions, in a reconnaissance for the triangulation of the Strait of Fuca. As this work would involve the occupation of a number of stations on Vancouver Island, Mr. Colonna, soon after his arrival, had called upon Lieutenant-Governor Cornwall, of the Dominion Government, at Victoria, British Columbia, and obtained, through the American consul, all necessary authority to land on the shores of British Columbia for the purposes of the survey.

By invitation of Lieut. Commander A. S. Snow, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Hassler, Mr. Colonna took up his quarters on board, the party on the Hassler being at that time engaged in erecting signals at the east end of the strait. With the advantages of transportation thus afforded, he became acquainted with the country as far west as Esquimalt Harbor. He then left the Hassler and took a trip on a tug to study the south shore as far as Nēēah Bay. Some means of transportation it became now absolutely necessary to have at his sole control in order to visit the more inaccessible places on the lower strait. A steamer of some kind would have been exceedingly desirable, but none being available at a reasonable cost, Mr. Colonna hired a fishing-boat, twenty-six feet long, and made arrangements to live on board. From the line Dungeness-Discovery, at the eastern end of the strait, he carried the reconnaissance to the line Slip Point-Sherringham Point, and was preparing to take the next step west, when, on the 9th of August, from the combined effects of overwork and an accident, he found himself paralyzed, and was taken to the hospital at Victoria.

In this emergency the arrival of Assistant Pratt with the schooner Yukon was exceedingly opportune; he was followed in a few days by Mr. T. P. Borden, who reported for duty as Aid. Messrs. Pratt and Borden prosecuted the reconnaissance with vigor to the westward in the Yukon.

On the 12th of September the vessel got under way for the lower straits, but, owing to calm weather and strong tidal currents, very slow progress was made in getting from point to point. Often, when nearing the shore, the wind would die out, and then there was great danger of shipwreck by being carried on the rocks by the strong and treacherous tidal currents, running, in some instances, as much as five or six miles an hour. On one occasion the Yukon was carried within twenty feet of the rocks at Beechey Head before her anchors would hold.

Mr. Pratt observes that during a great portion of the time there is a very heavy swell rolling in the straits, producing a heavy surf on the shores. These being mostly rocky, great skill and judgment are needed in managing a landing in a boat. To insure safety in landing, a steam vessel should be used. In a steamer the shore can be approached within one-third of a mile, and a reserve boat be held in readiness to render assistance to a landing party in case of accident.

During the ebb and flood tides in many parts of the strait there are tide-rips, which often cover large areas. These rips being composed of irregular and contradictory currents and eddies, combined with a heavy chop sea, small craft, and especially open boats, are always in great peril in them and are often lost.

Mr. Pratt's whole experience attested the truth of the statement of Captain Richards, R. N., in the Vancouver Island Pilot, who says of Juan de Fuca Strait that "from its geographical position it is liable to all those sudden vicissitudes of weather common to high northern latitudes, and in few parts of the world is the caution and vigilance of the navigator more called into action than in entering it."

There are no harbors west of Port Angelos on the American side, although there are several anchorages suitable during moderate or southerly weather. On the British side there is but one harbor, Port San Juan, west of Esquimalt, and that is exposed to southwest storms. Becher Bay should not be made in heavy weather, the tidal currents past its entrance being uncertain and often dangerous.

The reconnaissance, conducted by Assistants Colonna and Pratt with the aid of Mr. Borden, was completed by the middle of October, a scheme of triangulation having been developed from a proposed base on Whidbey Island to Cape Flattery light, on Tatoosh Island, on the American side, and to Bonilla Point, on Vancouver Island, British Columbia. The Yukon was laid up at Victoria, British Columbia, October 31. At this time Mr. Colonna was still in the hospital, but as soon as he had sufficiently recovered to bear removal he took up his quarters on board the Yukon, and by the end of the year was able to attend to office work.

A comprehensive report has been submitted by himself and Mr. Pratt, exhibiting the condition of the work at date (January 27, 1885), suggesting the most practicable methods for its execution, stating the modes of transportation most desirable, and giving estimates for its cost.

Mr. Colonna has presented also a special report of the work during its earlier stages. In this he expresses his thanks to Mr. Pratt for the spirit in which he came to his assistance in time of need, for the skill and energy with which he prosecuted the survey, and for his kindness and consideration to himself personally. Mr. Borden's services as aid were efficient and faithful.

Towards the end of May, 1885, in accordance with instructions, Mr. Colonna turned over the Yukon and all Coast and Geodetic Survey property on board of her in his charge to Mr. Pratt, and proceeded to Washington, stopping at Olympia, Washington Territory, long enough to acquaint Assistant J. J. Gilbert respecting the condition of the work on the Strait of Fuca, and to deliver to him such data as would enable him to continue it.

On June 8, he reported for duty at the office.

*Hydrographic survey of the Strait of Fuca.*—At the beginning of the fiscal year, as mentioned in the last annual report, a hydrographic survey in the Strait of Fuca was in active progress under the direction of Lieut. Commander A. S. Snow, Assistant Coast and Geodetic Survey, commanding the steamer Hassler. The lines run by the ship began in the near vicinity of Whidbey Island, and were carried across the strait, at intervals of two miles, as far as Pillar Point. In addition to these lines normal to the coast, two lines were run parallel to it; the various banks and shoals were developed, and close soundings were made in the vicinity of Puget Sound to connect with the inshore hydrographic work of previous seasons.

The boat work was carried on from New Dungeness light westward to Pillar Point; the lines being from one-third to one-fourth of a mile apart, with closer intervals wherever it seemed requisite. These lines were run out to a depth of twenty fathoms. Want of time prevented anything being done by the boats on the northern side of the strait except on Salmon Bank, which was quite closely and thoroughly sounded. Much trouble was experienced in getting the boats through the kelp, which grows very quickly in many localities, and the outer limit of which, as a rule, is in six fathoms water. No dangers were found outside of this kelp.

Lieutenant-Commander Snow gives in his report full details in regard to the harbors and anchorages within the limits of his hydrographic sheet. He observes that all of the anchorages are exposed to the easterly gales, but that these apparently do not blow home at Port Angelos, and from all other winds this harbor is admirably protected. He had been at anchor in the port when a heavy southeast gale was reported by telegraph twenty miles to the eastward, but with no indication of bad weather at his anchorage except a moderate swell, low barometer, and threatening sky. There is excellent holding ground, and good anchorage can be found anywhere on the southern side of the harbor.

The mountains of the Olympic Range, he remarks, have no special characteristic which can be described for the assistance of strangers navigating the strait, nor do the bluffs along the coast possess any peculiar features except in a few localities. At Pillar Point is a high round-topped hill, terminating in a high bare rock. Striped Peak, on the east side of Crescent Bay, is another conical hill, thickly wooded, and several hundred feet high. It has been conspicuous from a land slide, but the traces of this are gradually disappearing. These two points stand out quite prominently in the strait, the shore between them tending inward.

To obtain a plane of reference for the soundings, tide-gauges were put up at New Dungeness (just inside of the light), at Port Angelos, and at Griffin Bay, San Juan Island. Bench-marks were established for each gauge. Day and night observations for a lunar month were taken at Port Angelos. The gauge at this port was used for the greater part of the work, being more centrally located. Lieutenant-Commander Snow observes that the tides, although following the general law for the Pacific coast, are very irregular, and frequently perplexed him in endeavoring to follow them. It often happened in Port Angelos that there was no perceptible movement on the gauge for five or six hours, and but a few inches change throughout the day.

He suggests that a buoy on Salmon Bank would be a valuable aid to navigation, as the marks usually relied upon to keep clear of it cannot be seen at times when a buoy would be visible.

Respecting the currents in Fuca Strait, Lieutenant-Commander Snow remarks that they are very complex in their movements, and that observations of them to be of any value should extend over a long period, and be taken at regular intervals. As a rule, on the south side of the strait, with the flood tide, a vessel will be set slightly inshore of her compass course, while with the ebb, a set off-shore is noticed. Great caution should be used in the vicinity of the coast, especially near Race Rock, Point Wilson, and other projecting points where tide-rips are marked, and where a small change in position will make much difference in the set of the current.

In the vicinity of the banks the currents split in various directions, and heavy tide-rips are common, especially with fresh westerly winds.

Work was discontinued October 17, and, in pursuance of instructions, the Hassler steamed to Victoria, British Columbia, to take on board the American consul at that port and convey him to Port Townsend, Seattle, and Nēēah Bay, Wash. T., returning thence with the consul to Victoria.

This service having been performed, the Hassler left Esquimalt, British Columbia, on October 28, and arrived at San Francisco November 2.

The zeal and intelligence in the execution of duty displayed by the naval officers attached to the party elicited the warm approbation of their commander. Signals were erected and observations made by Lieut. G. Blocklinger and by Ensigns W. V. Bronaugh, F. M. Bostwick, and W. P. White. Records were kept by Passed Assistant Surgeon W. S. Dixon, and Assistant Engineer Edgar T. Warburton.

Following are the statistics of the season:

| | |
|---|---|
| Miles run in sounding | 843 |
| Angles measured | 3, 246 |
| Number of soundings | 5, 025 |
| Number of specimens of bottom preserved | 25 |

During the winter and spring the Hassler was thoroughly overhauled, and supplied with new boilers, a new false bottom under boilers and fire-room, &c. Towards the close of the fiscal year her commander was instructed to proceed to the coast of Oregon and continue the hydrography of that coast from a point near False Tillamook to the southward.

## SECTION XII.

### ALASKA, INCLUDING THE COAST AND ALEUTIAN ISLANDS. (SKETCH No. 13.)

*Hydrographic surveys in Southeastern Alaska.*—At the date at which this report closes, Lieut. Richardson Clover, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Carlile P. Patterson, was actively engaged in hydrographic surveys in the waters of Southeastern Alaska.

The Patterson left San Francisco April 25, 1885, and arrived at Port Simpson May 17. After landing material and working party for the steam tender Lively, and also a party for astronomical work, she proceeded the same day to Sitka to deliver a telegram from the Secretary of the Navy to the commanding officer of the U. S. steamer Pinta. On her return to Port Simpson May 26, the Lively and working parties were transferred to Ward's Cove, and on June 1 hydrographic work was begun on a sheet including Clarence Strait and the neighboring waters.

At the outset much difficulty was experienced in finding a site for a preliminary base line, the shores being densely wooded to high-water mark. After a thorough reconnaissance it was found necessary to go into Tongass Narrows, where a stretch of half a mile of beach was obtained at low water. The dense forests covering the approaches to the shores and the tops of the mountains made it impracticable to carry out a system of primary triangulation with long lines, and a series of small triangles had to be laid out, with frequent large signals at high-water mark.

Lieutenant Clover reports that the hydrographic characteristics of the locality are either very deep water or sunken rocks, which are frequently met with, and are exceedingly dangerous to navigation

A staff gauge for tidal observations was put up in Ward's Cove June 5, and observations taken day and night until June 17. A similar gauge was put up at the same time in Karta Bay anchorage, and by simultaneous observations of four low and four high waters the curve of this gauge was connected with that at Ward's Cove, and found to be the same. At Karta Bay, tidal observations were continued till June 28. The plane of reference for the soundings, as determined by a mean of the lower low waters observed during twenty-three days, was found to be 1.57 feet above the zero of the staffs. The extreme rise and fall observed was twenty-two and one-quarter feet.

Statistics of work to the close of the fiscal year upon the hydrographic sheet, scale 1-80000, extending from Cape Chacon to Cape Onslow, and from the east coast of Prince of Wales Archipelago to Na-ah Bay, in Behm Canal, have been furnished by Lieutenant Clover, and are as follows.

| | |
|---|---|
| Number of miles of shore line delineated | 104 |
| Number of stations occupied in triangulation | 28 |
| Miles run in sounding | 82 |
| Angles measured | 458 |
| Number of soundings | 5,399 |

The following named officers of the Navy were attached to the party: Lieut. J. M. Helm, Ensigns Walter McLean, C. C. Marsh, D. P. Menefee, A. P. Niblack, and T. G. Dewey.

Subassistant R. A. Marr was ordered to duty on the Patterson early in April, and had special charge of the determinations of geographical position and the magnetic work. On the voyage up, Port Townsend, Washington Territory, was connected by telegraph with Mare Island Observatory. Time observations were taken at Port Townsend on four days, at Port Simpson, British Columbia, on eight days; at North Base Station, Ward's Cove, Alaska, on eight days; at Karta Bay, Alaska, one day. At the two stations last named approximate determinations of latitude were obtained.

Observations for the magnetic declination, dip, and intensity were made on five days at Port Simpson, British Columbia, and on three days at Karta Bay.

The further progress of this survey will be stated in the next annual report.

*Tidal observations continued with self-registering tide-gauge at Saint Paul, Kadiak Island, Alaska.*—Assistant George Davidson, who has had the general supervision of the tidal work at Saint Paul, Kadiak Island, Alaska, reports that the record has been continuous, with the exception of a few breaks, unavoidable in training a new observer. For the first three months of the fiscal year, Mr. W. J. Fisher continued in charge of the gauge; he was succeeded by Mr. F. Sargent, who had already had some practice in managing it. The tabulations and original sheets are transmitted by the trading ships of the Alaska Commercial Company to San Francisco, and thence to Washington. Mr. Davidson acknowledges valuable assistance rendered to the new observer by Mr. Ivan Petroff, deputy collector of customs at Saint Paul.

## SECTION XIII.

### KENTUCKY AND TENNESSEE. (SKETCHES Nos. 1, 4, 5, 15, 17, and 18.)

*Reconnaissance for extending the primary triangulation near the thirty-ninth parallel from West Virginia into Kentucky and Ohio.*—Under the heading of Section III in this report an account has been given of the reconnaissance carried on by Assistant A. T. Mosman from stations in West Virginia westward near the thirty-ninth parallel into Kentucky and Ohio. Mr. Mosman was aided by Mr. J. E. McGrath. The reconnaissance was actively prosecuted until December 22, notwithstanding many interruptions from severe cold and storms. The scheme of triangulation resulting will be adopted for continuing the transcontinental geodetic work westward.

*Occupation of stations in continuation of the triangulation of the State of Tennessee.*—During the fiscal year the triangulation of the State of Tennessee was advanced by the occupation of four stations in the western part of the State by Prof. A. H. Buchanan, Acting Assistant. Instructions for field work were received July 9, 1884, and preparations were at once made for occupying station Deadening, about twelve miles northwest of Spring City, Rhea County. The establishment of camp, the posting of heliotropers, &c., was completed by July 21, and on the 22d observations were begun. Smoke and haze were very prevalent, and it was not till August 25 that the work at this station could be completed.

The party was then moved to Owen station, two and a half miles northwest of Sweetwater, Monroe County. At this point observations were begun August 31, and completed September 19. House station, twelve miles northeast of Knoxville, was next occupied. Observations at "House" were finished November 5. The last station occupied in 1884 was Melton, near Burns' Mill, Roane County. At Melton the party spent seventeen days, but the atmosphere was so smoky that during most of that time it was impossible to see ten miles, and but two days and a half of clear working weather were obtained. The exhaustion of the appropriation compelled Professor Buchanan to postpone the completion of the observations at Melton till another season. In June, 1885, this station was reoccupied, and the work there finished at the close of the fiscal year. At that date preparations for the occupation of another station were in progress.

## SECTION XIV.

OHIO, INDIANA, ILLINOIS, MICHIGAN, AND WISCONSIN. (SKETCHES Nos. 1, 4, 14, 15, 17, and 18.)

*Reconnaissance for extending the primary triangulation near the thirty-ninth parallel into Ohio and Kentucky.*—Reference has been made under the heading of Section XIII, and a full account given under the heading of Section III, of the reconnaissance prosecuted by Assistant A. T. Mosman in November and December, 1884, for the extension of the transcontinental triangulation near the thirty-ninth parallel westward into Ohio and Kentucky. The most westward point reached in the reconnaissance was West Union, Adams County, Ohio, near which a station was selected, connecting with Peach Mount, Ohio, and Cherry Ridge, Ky.

*Continuation of the triangulation of the State of Ohio.*—Geodetic operations in the State of Ohio were resumed, under instructions, by Prof. R. S. Devol, Acting Assistant, early in July, 1884. On account of delay in the passage of the appropriation act, and the smallness of the allotment, the season was a brief one. Arrangements were made by Professor Devol to take the field with as little delay as possible; tripods and observing scaffolds were built at Buck Hill and Brown stations, and upon their completion the party was organized at Barton station, about eight miles southwest of the town of Logan, in Hocking County. Observations at Barton were continued till August 30, when field work was closed. The weather was unfavorable during the greater part of the period; a severe drought prevailed, with very hazy atmosphere, till August 21. Six stations were observed from Barton, and the total number of angular measurements was four hundred and eighty.

Earthen pyramids for underground marks and marble posts for surface marks were put down at Brown and Buck Hill stations, and marble posts for reference marks at Barton station. Measurements there will be resumed at the close of the fiscal year.

*Occupation of stations in continuation of the triangulation of the State of Indiana.*—Results of the field operations for the extension of the triangulation of the State of Indiana under the direction of Prof. J. L. Campbell, Acting Assistant, show the completion of measurements in the first quadrilateral, the occupation of two stations in the second quadrilateral, and a reconnaissance begun for the selection of stations in a third quadrilateral.

Four stations were occupied for angular measurements during the season—Blind Asylum Six-Mile Switch, Sims, and Lutz. By the occupation of the three stations first named, the surveys of the States of Indiana and Kentucky have been brought into close geodetic connection. Lutz is a station of the second quadrilateral north of the Ohio River. It is a few miles south of the town of Charlestown, Clark County, and is less than half a mile east of the line of the Ohio and Mississippi Railroad. At this station it was found necessary to erect a tripod and tower, forty feet in height. The other new station selected, but not occupied this season, was named Haystack. It is a little to the west of the town of Bennettsville, in Clark County; has an approximate elevation of nine hundred and ten feet above sea-level, and is a prominent and well-known part of the elevations known as "The Knobs."

Special care was taken to secure these stations by underground and surface markings. For the underground marks a one-eighth-inch copper wire was firmly set in cement in a black bottle, and the bottle placed in a ten-inch stone tubing and filled round firmly with gravel and cement two feet below the surface. Four limestone pillars were employed for the surface marks, one located directly over the center of the underground mark, and the three others six feet distant from the center, to the north, south, and east. These pillars are two feet long, dressed at top to five inches square, and show about four inches above the surface.

Field operations were closed in October. In the prosecution of the work Professor Campbell had efficient aid from Prof. J. N. Coulter. The statistics are:

| | |
|---|---|
| Number of principal angles determined | 12 |
| Number of subordinate angles determined | 9 |
| Number of observations for principal angles | 138 |

In June, 1885, work was resumed by Professor Campbell. He began a reconnaissance for advance stations, made a selection of one point, and at the end of the fiscal year was carrying forward the work of construction of an observing tripod and scaffold.

*Extension of the primary triangulation near the thirty-ninth parallel eastward across the State of Illinois.*—At the beginning of the fiscal year the primary triangulation near the thirty-ninth parallel in the State of Illinois had been advanced by Assistant George A. Fairfield nearly to the eastern boundary of the State. Before the first station could be occupied it became necessary to erect tripod and scaffold signals of seventy-five and eighty feet in height, one at Honey Creek station in Illinois and one at Summit station, Indiana. All preparations were completed by July 12, and the party of observation went into camp at Claremont station, which is situated four miles east and two miles north of Olney, Richland County.

On August 5, Assistant J. S. Bradford reported for duty in the party, and on the 24th, Extra Observer J. B. Boutelle joined it. Observations at Claremont were finished August 26, and a day or two later camp was moved to Hunt City station, which is about a mile northeast of the railroad station of the same name on the Danville, Olney and Ohio River Railroad. Twelve days sufficed to complete the work at Hunt City, and by September 26 the party was established in camp at Belle Air station, twelve miles south of Martinsville, on the Vandalia Railroad. A week of rainy weather delayed operations, but as only three directions had to be determined from this point, the occupation of the station was completed October 7, and on the 11th camp was pitched at Honey Creek station, about five miles northwest of Flat Rock, a small town on the Cairo division of the Wabash, Saint Louis and Pacific Railroad.

The next and last station occupied during the season was Summit, which is situated about nine miles northeast of Vincennes, Ind. Observations were begun November 4, but delays occurred, owing to the bad condition of the atmosphere and accidents to the night-observing-lights. On November 10, in pursuance of instructions, field work was closed for the season.

At three of the stations occupied signals had been erected in 1879 by the United States engineers, by whom a triangulation had been carried southward from stations of the Lake Survey. Mr. Fairfield found these signals to be in a good state of preservation. They had been built in the most substantial manner, and by occupying them he was enabled to make a very satisfactory connection between the Coast and Geodetic Survey transcontinental triangulation and that of the Engineer Corps, U. S. A. These stations were: Claremont, where the instrument was mounted at a height of eighty feet; Hunt City, where it was seventy-five feet, and Belle Air, where it was one hundred feet above the ground. Two of the lines in Mr. Fairfield's scheme, Denver to Claremont and Hunt City to Belle Air, were identical with lines of the Engineer Survey.

Three signals yet remain to be observed upon to carry the work entirely across the State of Illinois.

The statistics are:

| | |
|---|---|
| Primary stations occupied | 5 |
| Primary signals observed upon | 9 |
| Secondary objects observed upon | 8 |
| Observations for horizontal directions | 1,676 |

During the winter and spring Mr. Fairfield was occupied in office work, and towards the close of the fiscal year was directed to visit certain primary stations on the coast of Maine and report what steps would be necessary for their preservation. Subsequently he received instructions to resume work on the transcontinental triangulation.

*Progress made in connecting the line of transcontinental leveling with a point on the Gulf coast.*—In furtherance of the work of ascertaining the relative levels of the Atlantic and of the Gulf, by running lines of leveling of precision from a point on the transcontinental line of levels towards Mobile, Assistant J. B. Weir proceeded, under instructions, to Odin, Marion County, Illinois, and on the 10th of April, 1885, began work from a bench-mark established by Assistant Braid in 1882. To make the starting point more secure, Mr. Weir established another permanent bench-mark at Odin.

From Odin the line of levels followed the track of the Illinois Central Railroad, and the trains of that road were used as a means of daily transportation to and from the localities of work. At Villa Ridge, Pulaski County, twelve miles north of Cairo, where field operations were closed June 5, two permanent bench-marks were established.

Between Odin and Villa Ridge, a distance of one hundred and nine miles, fourteen permanent bench-marks were established. The method of observing was the same as hitherto pursued in this work. Two parallel lines were run simultaneously and in the same direction with separate rods, these rods being placed at different distances from the level. In order to eliminate any cumulative error that might result from running constantly in one direction, alternate portions of the line, of ten or fifteen miles in length, were run in opposite directions, care being taken to have the back and fore sights as nearly equal as possible.

The original and duplicate records of the work have been transmitted to the office.

Mr. Weir, in his report, acknowledges the effective services rendered by Mr. John Nelson, who served as Aid in the party.

*Occupation of stations in continuation of the triangulation of the State of Wisconsin.*—In continuation of the triangulation of the State of Wisconsin, Prof. John E. Davies, Acting Assistant, took the field under instructions at the earliest date at which the appropriation became available. Between July 21 and October 28, when the season closed, four stations were occupied in the southeastern part of the State, and a connection was established with the triangulation of the U. S. Lake Survey. High tripods were built at Lebanon, Delafield, and Geneva Lake preparatory to the occupation of the first station, Oakland. Following this, stations Delafield, Erin, and Pleasant Springs were occupied in succession, and the occupation of station Lebanon attempted, but without success, owing to the vibration of the tall observing tripod and scaffold in the prevailing high winds. An effort will be made next year to give greater steadiness to this structure.

As the lines Lebanon-Erie-Delafield are all well established and adjusted lines of the Lake Survey, based upon carefully measured and fundamental lines at Fond-du-lac and Chicago, a close coincidence of results upon those lines would be highly gratifying, and was so, as far as the observations obtained would indicate.

Professor Davies devotes much space in his report to the recommendation of methods which appear to him highly desirable for greater efficiency and economy in the prosecution of the survey, and for the security of the stations already determined, especially those bordering upon the States of Iowa and Illinois, and upon Lake Michigan.

The statistics of his season's work are:

| | |
|---|---|
| Number of horizontal angles measured | 83 |
| Number of repetitions | 3,222 |
| Number of vertical angles measured | 19 |
| Number of repetitions | 684 |

## SECTION XV.

MISSOURI, KANSAS, IOWA, NEBRASKA, MINNESOTA, AND DAKOTA. (SKETCHES Nos. 2, 15, 17, and 18.)

*Occupation of stations for continuing to the westward the primary triangulation in Missouri and Kansas.*—At the beginning of the fiscal year Assistant F. D. Granger had organized his party in the field in Western Missouri for the continuation of the primary triangulation in Missouri and Kansas, and was occupied in superintending the construction of the high observing tripods and scaffolds required at the stations Haskin, Thomas, Bebe Mound, and Eckman. All of these stations are in the eastern part of Kansas, to the south, southwest, and west of Kansas City, Mo.

It became necessary, however, early in July, owing to the reduction of the appropriation for the transcontinental work, to modify Mr. Granger's instructions, and to limit him to the occupation of two stations, Bowler and Berry, in Western Missouri, from which could be determined the first two stations of the scheme to the westward, Marty and Haskin.

Bowler station is on a small elevation, situated about two miles and a half southwest of the town of Lee's Summit, Jackson County, Missouri. Station Berry is about one mile and a half west of the town of Belton, Cass County, Missouri.

At Bowler the theodolite was elevated twenty-seven feet above ground, and five primary and eight tertiary directions were determined. At Belton the elevation of the theodolite was twenty-four feet. Observations were made upon four primary and six tertiary objects, and by September 1 all of the work required at the two stations was finished.

Before disbanding his party, Mr. Granger visited stations Haskin and Marty to secure them by permanent markings.

The tertiary objects determined were church spires in the towns of Harrisonville, Lee's Summit, Westport, Kansas City, and Independence.

The statistics are:

| | |
|---|---|
| Number of observations for horizontal directions | 922 |
| Number of observations for elevations, by double zenith distances | 98 |
| Number of observations for differences of heights by micrometer | 325 |

In September Assistant Granger was directed to report for duty in the party of Assistant A. T. Mosman. Mention of this service has already been made under the head of Section III. Upon being detached in October he was ordered to special duty at the office.

*Determination of the longitude of Kansas City, Mo.*—Under the heading of Section VIII an account has been given of the work of the two primary longitude parties, organized in March, 1885, for the determination in longitude of stations in Texas, Arkansas, and Missouri. Towards the end of May, Assistant Edwin Smith, who had been placed in general charge of the work, and in immediate charge of one of the primary parties, had determined the longitude of Little Rock, Ark., and had made the necessary arrangements for an exchange of telegraphic signals for longitude with Assistant C. H. Sinclair, in charge of the other primary party at Kansas City, Mo.

On the nights of May 30, 31, June 1 and 4 successful exchanges of longitude signals were obtained by the two observers. They then changed stations, Mr. Smith proceeding to Kansas City and Mr. Sinclair to Little Rock. In the new position of observers the determination of the longitude of Kansas City was completed by exchanges on the nights of June 11, 12, 18, and 19. The results for longitude of the primary points being freed from the effect of personal equation by the exchange of observers, no special observations were needed for personal equation between Messrs. Smith and Sinclair.

All of the records and field computations of the season's work have been transmitted to the office.

## SECTION XVI.

NEVADA, UTAH, COLORADO, ARIZONA, AND NEW MEXICO. (SKETCHES Nos. 2, 15, 16, 17, and 18.)

*Continuation of reconnaissance and triangulation in Utah, near the thirty-ninth parallel.*—Assistant William Eimbeck was engaged at the beginning of the fiscal year, as mentioned in my last annual report, in a reconnaissance for the site of a base line in Central Utah that should be so located as to be available for connection with the primary transcontinental triangulation near the thirty-ninth parallel. This work involved a reconnaissance of the mountains northeastward from Ogden, which was subsequently carried into the valley of the river Jordan and to the foot-spur mountains bordering that valley to the east. Mr. Eimbeck had in view also the extension of the geodetic scheme northward from the line Ibepah—Mount Nebo. Having brought these examinations to a close early in July, and submitted for official decision two proposed locations for primary bases, he next carried a reconnaissance into the San Pitch Mountains, between Juab and San Pete Valleys, and thence to the Wasatch Plateau opposite the towns of Manti and Ephraim, San Pete County. All of this reconnaissance was virtually brought to a satisfactory conclusion by the end of July, and the results duly reported. These results were, the establishment of the intervisibility of the points of the great quadrilateral, Ibepah (or Gosiute), Nebo, Pilot Peak, and Ogden, and a scheme of triangulation connecting the base-lines referred to with the main work.

In August Mr. Eimbeck submitted for consideration a scheme of telegraphic longitude stations covering a section of the arc of the thirty-ninth parallel from the meridian of Colorado Springs to the Pacific coast.

Upon the receipt in that month of telegraphic instructions approving and adopting the Juab base, he proceeded to organize a full party for the occupation of Scipio, one of the stations connecting with the south end of that base, and for the erection of the necessary signals to be observed upon at Cedar, Levan, San Pete, and South Juab. The plan of occupying Ibepah station was abandoned for the time being, owing to the advanced state of the season and the unusual isolation and inaccessibility of that mountain from the eastward.

Upon the 16th of August an advanced party was dispatched to Scipio station, a mountain upwards of five thousand feet in height, for the purpose of opening a trail for the pack animals, and by the end of that month the party was encamped near the summit, and the station was in readiness to receive the instruments. It was not, however, till the atmosphere had been cleared by a snow storm on the 10th of September that observations of horizontal directions could be begun. Heliotropes had been established at Nebo, Wasatch, and Mount Tushar; at all other stations flat, rectangular, and target-like signals were erected, such as had proved most effective as regards visibility on former occasions upon lines of fifty or sixty miles long.

At Scipio station the work included, besides observations of horizontal direction, observations of zenith distances, both absolute and differential, a complete set of magnetic and meteorological observations, and a rough topographical survey of the mountain, covering an area of at least ten square miles.

Before the close of field operations complete sets of magnetic observations, extending in each case over three days, were made at Deseret Railway station, Utah Central Railroad, and at Salt Lake City, where the Temple Block magnetic station was occupied to obtain the regular annual set of observations, this being deemed one of the base stations of the magnetic survey. At stations Nephi and Provo, which had been established and occupied the year before, the magnetic dip only was observed.

Field work was closed finally for the season in October, and, under instructions, Mr. Eimbeck proceeded to Washington and reported for duty at the office. The Aid in his party, Mr. George F. Bird, who had served creditably since being assigned to it, July 23, was detached and ordered to Kansas City. Mr. Bird had made all of the magnetic observations, the measurements of absolute zenith distance, and the topographical survey of Scipio station.

Owing to the shortness of the field season and unfavorable weather, the experiments with the "selenotrope," which Mr. Eimbeck had undertaken for the first time the preceding season to test the practicability of using the moon's light for geodetic night-signals, were not resumed, but will be as opportunity offers.

While engaged on office work during the remainder of the fiscal year Mr. Eimbeck submitted designs for a new form of base apparatus, and designed and reported also a new form of suspension for pendulums used for determinations of gravity.

Towards the end of June he received orders to prepare for the resumption of field work in Central Utah.

## SPECIAL OPERATIONS.

*Examination of methods of observation and photographic processes employed at the Magnetic Observatory, Toronto, Canada.*—Upon being relieved from the charge of the Magnetic Observatory at Los Angeles, Cal., Assistant Marcus Baker was ordered to proceed to Philadelphia and thence to Washington for conference with the Superintendent. Considerations based upon the desirability of improving the methods of photographic registry employed at Los Angeles led to the issue of instructions to Mr. Baker to proceed by way of Toronto, Canada, and obtain from Mr. Charles Carpmael, director of the Magnetic Observatory of the Dominion Government, permission to inspect the processes of photographic registry and development employed in that establishment.

On his journey east, Mr. Baker availed himself of a short stay at Kalamazoo, Mich., to determine the magnetic declination at that place.

Arriving in Toronto, August 25, Mr. Baker, finding the Director of the Observatory absent, was presented to Mr. James Young, his assistant, who had special charge of the magnetic work and the photographic processes, and was indebted to his courtesy for the privilege of examining the observatory and many of the details of its operations.

The results of this examination, and of studies and experimental investigations made during the winter and spring in Washington, with valuable aid and suggestions from Assistant Andrew Braid, led, in April, to a recommendation that argentic gelatino-bromide paper should be substituted for the bromo-iodide of silver paper then in use at Los Angeles. The change was effected, as stated under the heading of Section X, on the 1st of June, 1885, and the improvement in the character of the photographic traces has been very gratifying.

REPORTS IN REGARD TO THE SUBOFFICES AT BOSTON, NEW YORK, AND PHILADELPHIA.

*Suboffice at Boston.*—The relation of Assistant Henry Mitchell to certain harbor commissions in Massachusetts and other New England States led many years ago to the establishment of working rooms in Boston for himself and party. These rooms, two in number, came eventually to be a place for the collection of data, and for the computation of the results of physical surveys, and in 1881, under the new regulations issued in that year, were designated as a "suboffice."

Those that seek this suboffice, Mr. Mitchell reports, are mostly professional men, interested in commerce or navigation, and in the studies of physical hydrography there pursued ; it is not, practically, a source of general information. He submits for consideration the conclusion that in view of the success of the work, the suboffice in Boston has been economically conducted, and under favorable conditions.

*Suboffice at New York.*—At the solicitation of the Chamber of Commerce, the Maritime Exchange, and the Produce Exchange of the city of New York, a suboffice was established in that city in May, 1885. The use of the building formerly occupied by the Produce Exchange, on Pearl, and Water, and Whitehall, and Moore Streets, was granted by that body free of charge to the Government. In view of the detailed resurvey of New York Harbor and its approaches, which was then in progress, and of the advantage of having a general headquarters where chiefs of parties could meet to arrange details of co-operation, and where charts of the harbor could be made accessible for reference, the Superintendent accepted with thanks the liberal offer of the Produce Exchange, and placed the arrragement and care of the office rooms in charge of Acting Assistant Francis J. Palmer.

It was believed also that the value of the work done by the Survey would have a wider recognition and more extended appreciation by the establishment of a suboffice in the most important maritime port of the United States.

At the date at which this report closes, part of Mr. Palmer's time was, occupied, with the approval of the Superintendent, in supervising the construction of a series of models, in relief, of the harbor and its approaches upon scales of three, eleven, and twenty-four inches to the mile, respectively. The expense of making these models was borne by members of the committee on harbor and shipping of the Chamber of Commerce. For the information of this committee Mr. Palmer had been previously engaged some months in examining and collating the various surveys of the harbor, and in collecting and arranging all of the publications which could be found bearing upon the subject.

The opening of this suboffice has developed the interest of all classes of the citizens of New York in the care, preservation, and improvement of the harbor, and has shown that they are heartily in sympathy with its thorough resurvey.

*Suboffice at Philadelphia.*—The use of a large and well-lighted room in the new post-office building in Philadelphia having been kindly accorded to the Survey, mainly through the efforts of Assistant S. C. McCorkle, the opportunity was taken of supplying a want long felt in some of the leading sea-ports, namely that of bringing the work and the results of the Survey into closer relations with the commercial and maritime community, and of establishing a bureau of information, where a supply of the charts and other publications could be kept for reference, and where inquiries in regard to the operations of the work could either be answered or referred to the proper officers.

At the beginning of the fiscal year, Assistant McCorkle was instructed to take charge of this suboffice, and he has submitted a report of its operations to June 30, 1885. Applications for information have been received, and inquiries answered from the Department of Surveys of the city of Philadelphia, from the Water Department, the Board of Port Wardens, the Maritime Exchange, and the Board of Trade. Also from the officers of the Engineer Corps, U. S. A., of the Light-House Board, and Signal Service. Much advantage is derived from having the offices of these several Government bureaus under the same roof.

Those assistants of the Survey whose duty brought them to the city were afforded facilities for doing office work, and their instruments and records were stored temporarily, free of cost, in a fire-proof building. Assistants Henry Mitchell, R. M. Bache, C. M. Bache, C. T. Iardella, R. E. Halter, Edwin Smith, F. W. Perkins, H. L. Marindin, C. H. Sinclair, and C. H. Van Orden availed themselves from time to time of these facilities.

During the sessions of the American Association for the Advancement of Science, in September 1884, and during the period of the International Electrical Exhibition, in the autumn of that year, invitations were extended to the delegates and to the exhibitors to visit the office. Many responded and showed great interest in the charts, Coast Pilots, and tide-tables, and particularly in the model of the Depths of the Sea in the Bay of North America and Gulf of Mexico, which the Superintendent had sent for a time to the suboffice before placing it in the New Orleans Exposition.

A description of this model, with illustrative sketch, was given in Appendix No. 17 to the last annual report.

Mr. McCorkle expresses his belief that the interest of the public in the work of the Survey has been greatly advanced by the establishment of the suboffice in Philadelphia.

*Charge of the exhibit of the Coast and Geodetic Survey at the New Orleans Exposition.*—A special building for the use of the Government having been erected by the managers of the World's Industrial and Cotton Centennial Exposition held at New Orleans in 1884–1885, arrangements were made by the Treasury Department for exhibits by several of its Bureaus. Preparations were begun in the autumn of 1884 at this office for sending to New Orleans an exhibit which should illustrate the instruments and apparatus used in the Coast and Geodetic Survey, and the results of its work. Occasion was at the same time taken to prepare for transmission sets of Standards of Weight and Measure.

These preparations, under the general supervision of Assistant C. O. Boutelle, in charge of the office, were directed in detail by Assistant Henry W. Blair, who had been assigned to the charge of the exhibit of the Survey. Mr. Blair had arrived at Nashville early in December, having, with characteristic energy, started southward before having fully recovered from the effects of severe illness. At Nashville he was prostrated by an attack which proved fatal in a few days. Assistant George W. Dean was at once instructed to proceed to New Orleans, where he arrived December 17, and reported to Mr. William F. MacLennan, the representative of the Treasury Department in the Board of United States Executive Officers. Dr. James J. Clark, of the Office of Standard Weights and Measures, had already arrived and co-operated with Mr. Dean in the arrangements for the disposition of the exhibit, the space for which, though limited, was favorably located near the main entrance on the west side of the Government building.

The articles forming the exhibit were in place by the middle of January, 1885. They were classified under the heads of geodesy, astronomy, topography, hydrography, magnetics, miscellaneous, publications and results, and weights and measures.

The instruments and apparatus used in geodetic work were represented by the primary six-meter compensating base apparatus, by a four-meter secondary base apparatus, by two theodolites one sixteen inch and one eight inch, by reconnoitering telescopes, by heliotropes, by a geodesic level and a gradienter, and by signal lamps used for night observations.

The astronomical branch of the work was illustrated by a complete set of instruments used in determining latitude and longitude, and included a zenith telescope, a forty-six inch transit, a prismatic transit, an electric chronograph, a break-circuit chronometer, telegraphic key-board, and apparatus for determining personal equation.

Topographic work was represented by a plane-table complete in all of its parts and a telemeter rod; hydrographic work by a sextant, and optical densimeter, a deep-sea thermometer, and a self-registering tide-gauge.

The instruments illustrating the magnetic branch of the Survey were a unifilar magnetometer and a dip-circle.

Under the head of "miscellaneous" were shown a pendulum, a geodesic level and rod, a maximum and minimum thermometer, a stoppered level, and a tripod and scaffold model for an observing signal.

The publications of the Survey were illustrated by a set of the volumes of annual reports and by copies of scientific papers, by volumes of the Coast Pilots for the Atlantic and Pacific coasts, by copies of tide tables, and by a catalogue of upwards of six hundred charts, with specimen copies of charts on the various scales of publication. Also by a model of the Depths of the Sea in the Bay of North America and Gulf of Mexico. A description of this model, with sketch, is given in Appendix 17 to the report for 1884.

Complete sets of standard weights and measures, according to the English system, as ordinarily used in the United States for commercial purposes, were exhibited; also a complete set of standards of weight and measure of the metric system, as legalized by act of Congress. Two com parators were shown, both for comparisons of end measures; one a vertical comparator, for the comparisons of end measures with a working standard during adjustment, the other a reflecting comparator, used for final comparisons of standards of length.

Several hundred copies of a pamphlet which had been prepared at the office, descriptive of the Coast and Geodetic Survey exhibit, were distributed to visitors who evinced special interest in the character and progress of the work.

Assistant Dean has submitted a full report of his connection with the exposition. Upon being relieved at his own request in March the charge of the exhibit was temporarily assigned to Dr. J. J. Clark, whose efficient and faithful services Mr. Dean acknowledges in his report. Towards the end of March Assistant C. H. Boyd was assigned to duty at New Orleans in place of Mr. Dean, and remained till the close of the exposition, May 31.

*Voyage of the new steamer C. P. Patterson from the Atlantic to the Pacific coast.*—Reference was made in the last annual report to the construction of a steamer, the Carlile P. Patterson, specially designed for service on the Pacific coast. Before the Patterson left Hampton Roads for the Pacific, July 30, 1884, several trial trips were had with very satisfactory indications. Full reports have been submitted in regard to the results of her six months' voyage to the Pacific, the varying conditions of which compelled tests of her sea-going qualities much more complete and trustworthy than could be obtained in short trial trips. One of these reports has been prepared by Commander C. M. Chester, U. S. N., Hydrographic Inspector, who superintended the construction of the steamer. From the other report, submitted by her commander, Lieut. Richardson Clover, U. S. N., has been condensed the following account of her voyage from Montevideo to Valparaiso:

"The Patterson is of about eight hundred tons displacement, bark rigged, and capable of steaming nine knots on a consumption of eight tons of coal a day, and seven knots on four and one-half tons of coal a day in smooth water. Leaving Montevideo, Uruguay, at noon of November 6, 1884, with bunkers full and thirty tons of coal on deck, the steamer encountered a heavy gale near the mouth of the river, which compelled her to lay to the best part of a day, but though deeply loaded she rode quietly the heavy seas without taking anything but a little spray on deck. Variable weather with strong gales continued till the 14th, when the Straits of Magellan were entered with pleasant weather, the steamer passing between Virgin Reef and Nassau Rock."

Lieutenant Clover gives a detailed account of his passage through the straits, which at times was not unattended by danger. On the morning of the 17th, leaving his anchorage at an early hour, he passed down Famine Reach, and on rounding Cape Froward was met by a tempest blowing down Froward Reach. With a favorable current, he struggled against the wind and sea from 11 a. m. till 5 p. m., hoping that the wind would go down enough to allow him to get to Wood's Bay, if not to Port Gallant, but during these six hours he made but five miles. The wind was so violent that the sea would be picked up bodily, and whirled into fine spray like a snow drift. At one time the wind got the vessel on the bow, and in order to keep her from running straight into the shore, her commander was compelled to back and wear short around, and came near losing both steam launches in bringing her again to the wind.

Two days later the Patterson steamed through Victory Pass into the Pacific.

While at anchor in the straits off Sandy Point, a town of fifteen hundred inhabitants, and the nearest town in the world to the South Pole, Captain Mendez, of the Argentine Navy, Military Governor of Staten Island and Terra del Fuego, visited the vessel, and from him much valuable information was obtained.

Off the Pacific coast soundings were taken with the deep-sea machine, and reported dangers searched for. On November 29 the Patterson reached Talcahuano, Chili, where she remained a week to refit, and December 7 left for Valparaiso, arriving at that port the next day. Immediately upon her arrival at San Francisco, February 13, 1885, Lieutenant Clover began preparations for the hydrographic work which had been assigned to him in Southeastern Alaska. A report of this work to the close of the fiscal year will be found under the heading of Section XII.

Commander Chester states that in the qualities needed for effective service in Alaskan waters the Patterson has exceeded his most sanguine expectations. He bases this conclusion upon the reports received from her commander, and upon an elaborate discussion of her stability, the data for which were obtained by experimental trials at the Washington Navy-Yard.

*Tidal observations at Honolulu, Sandwich Islands.*—Records have been received at this office up to June 28, 1884, from the self-registering tide-gauge loaned in 1877 for the use of the Hawaiian Government Survey. This gauge is in operation at Honolulu, Oahu, under the supervision of the Superintendent of that Survey, and its records will be of much value in the discussion of the tides of the Pacific.

## COAST AND GEODETIC SURVEY OFFICE.

The report of the Assistant in charge of the Office, Charles O. Boutelle, esq., which appears in Appendix No. 4, and the accompanying reports of the chiefs of the office divisions, give all details relating to the office operations during the fiscal year.

Mr. Boutelle refers to the valuable contribution to our knowledge of the earth's magnetism made in Assistant Schott's paper on the secular variation and geographical distribution of the magnetic dip and intensity in the United States for the epoch, 1885. 0. Also to the improvements effected in the engraving, electrotyping, and printing divisions under the charge of Assistant Ogden. Improved batteries were introduced for electrotype work, by means of which a more uniform and regular deposit of copper was obtained on the engraved plates, experiments having shown that a dynamo was not well adapted for this purpose. Increased facilities for the printers were obtained by an addition to the printing-office, affording better light and ventilation, and room for the new presses needed to meet the demand for charts.

In the tidal division, the tide-predicting machine, invented by Professor Ferrel, has proved to be of great value in reducing to a minimum the labor of computation. It was used largely in the preparation of the tide tables for the Atlantic and Pacific coasts for 1886, which are now published. Mr. Boutelle alludes to some records of exceptional interest received in the office during the year from three widely separated tidal stations in the Pacific Ocean. At the self-registering tide-gauges near San Francisco, at Kadiak in Alaska, and at Honolulu in the Sandwich Islands, the waves from the great Krakatoa earthquake of August 26, to September 2, 1883, were distinctly recorded. Photographic copies of these records, which will be of value in determining the movement of the earthquake waves, have been forwarded to the Royal Society, London.

The preparation of original topographic sheets for reproduction by photolithography has had special attention during the year in the Drawing Division and with marked success.

All calls for information received from the several Departments of the Government have been promptly met, and requests from private organizations or individuals for transcripts from the records of the Survey have when practicable been granted. A tabular statement of information furnished is given in Appendix No. 3, and a table of the statistics of the Survey to the close of the fiscal year in Appendix No. 2.

The measurement of the areas of all salt and fresh marsh upon the Atlantic Gulf coast, alluded to in the last annual report as having been undertaken at the request and for the use of the Commissioner of Agriculture, was completed, and the results communicated to that officer.

Mr. Boutelle expresses his great personal indebtness to Assistant H. W. Blair, who served as his immediate executive officer and adviser from the beginning of the fiscal year till he was seized with an illness which after a few months proved fatal. A tribute to the memory of this able young officer appears in Appendix No. 18.

Assistant C. H. Sinclair was temporarily assigned to duty in Mr. Blair's place, and served till relieved in August, 1884, by Subassistant F. H. Parsons, who remained on duty till the close of the fiscal year.

Mr. William H. Dall resigned his position as an Assistant in the Survey in September, 1884, in order to devote himself more exclusively to biological investigations. Mr. Dall had been connected with the Survey since 1871. His explorations in Alaska, resulting in his work, "Alaska and its Resources," published in 1870, and his assignment to duty on that remote coast for a number of years after his appointment, caused him to be recognized as an authority in all matters pertaining to the territory. In 1879 the Survey published as an Appendix to the Pacific Coast Pilot an elaborate work, compiled and edited by him, on the meteorology of Alaska, with a partial list of maps and charts relating to it and the adjacent regions, and an exhaustive bibliography. In 1883, under his editorship, the Survey published the Alaska Coast Pilot, Part I, from Dixon Entrance to Yakutat Bay.

For valuable aid in the preparation of these works, Mr. Dall acknowledges his obligations to Assistant Marcus Baker, who had served with him on the Alaskan peninsula. After Mr. Dall's resignation took effect, all Alaskan material in his hands was turned over to Mr. Baker, and by direction of the Superintendent he was charged with the revision of charts and sailing directions resulting from hydrographic reconnaissances in the Alexander Archipelago. He was occupied also during the winter and spring with tidal investigations and special correspondence relating to the tides. In October he was instructed to visit Sandy Hook automatic tide-gauge and restore its efficiency, and in February, 1885, he prepared a preliminary report upon the character and condition of all tidal observations obtained in the Survey to the close of 1884. In May he was assigned to duty on the New York Harbor resurvey.

Reference was made in the report for 1883 to the detail of Subassistant E. D. Preston as a member of the Eclipse Expedition to Caroline Island, South Pacific Ocean, and to his return to San Francisco, and the comparative determinations of gravity made by him in July and August, 1883, at the station in that city established by Assistant Davidson.

In the report for 1884 it should have been stated that Mr. Preston, upon being ordered to the Atlantic coast, was employed on miscellaneous duty in the office of the Superintendent from September 1, 1883, to January 15, 1884. During this time he investigated the relative accuracy of superposition and contact in micrometric pointings; determined the equatorial intervals of transit No. 5 for the use of the French Transit of Venus Commission; reviewed the longitude work between Savannah, Ga., and Saint Augustine, Fla., and finished his computations for the report of Professor Holden on the Total Solar Eclipse of May 6, 1883.

On January 15, 1884, Mr. Preston was granted six months furlough to proceed to Cordoba, Argentine Republic, South America, to aid Dr. Gould on his work on the Southern Stars.

In the office of Assistant in charge the clerical duties were very acceptably discharged by Dr. W. B. French, who had also the entire care of the office accounts, including the returns of money received for sales of charts.

Mr. W. B. Chilton served as clerk and Mr. C. D. Gedney as stenographer in the office of the Superintendent.

Mr. W. B. Morgan continued on duty as disbursing agent of the Survey, with Mr. J. W. Parsons as accountant and Mr. V. J. Fagin as examiner.

CONCLUSION.

In the preparation of this report, and in the editing for publication of the last annual report and appendices thereto, Assistant Edward Goodfellow rendered service throughout the year. The report for the fiscal year ending with June, 1884, a volume of upwards of six hundred pages quarto, with twenty-five progress sketches and illustrations, ordered printed by Congress in February, 1885, was published in November, and is now ready for distribution. Extra copies of papers of special interest or practical value to surveyors, geodesists, and others, published as appendices to this report, had previously been supplied by the Public Printer.

Events which led to my appointment as Superintendent in July last, and subsequently to the resignation by Mr. J. E. Hilgard of that position, have devolved upon me the duty of presenting this report to the Department.

Respectfully submitted.

F. M. THORN,
*Superintendent.*

Hon. DANIEL MANNING,
*Secretary of the Treasury.*

# PART III.

# APPENDICES.

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# APPENDIX No. 1.

*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 with June, 1885.*

| Sections. | Parties. | Operations. | Persons conducting operations. | Localities of work. |
|---|---|---|---|---|
| SECTION I. | | | | |
| Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island, including coast and seaports, bays and rivers. | No. 1 | Topography ...... | Charles H. Boyd, assistant; Henry R. Taylor. | Machias Bay entrance, Machiasport and coast to the eastward. |
| | 2 | Topography ...... | Eugene Ellicott, assistant; J. H. Turner, aid. | Chandler's Bay and Englishman's Bay shore-lines, coast of Maine. (See also Sections III and VI.) |
| | 3 | Hydrography...... | Lieut. E. D. F. Heald, U. S. N., assistant; Ensigns T. D. Griffin, A. Jeffries, and W. C. Canfield, U. S. N. | Narragaugus River, Harrington River, and Pleasant Bay and river, Maine. (See also Sections VI and VIII.) |
| | 4 | Topography ...... | A. W. Longfellow, assistant, E. F. Dickins, assistant. | Prospect Harbor and Mount Desert Island, Maine. |
| | 5 | Tidal observations | J. G. Spaulding ...... ............ | Record of observations with self-registering tide-gauge continued, and meteorological observations recorded at Pulpit Cove, North Haven Island, Penobscot Bay. |
| | 6 | Hydrographic examinations. | Lieut. J. E. Pillsbury, U. S. N., assistant. | Coasts of Maine, New Hampshire, and Massachusetts. (See also Section VI.) |
| | 7 | Geodetic operations. | Prof. E. T. Quimby, acting assistant | Continuation of the triangulation of the State of New Hampshire. |
| | 8 | Geodetic operations. | Prof. V. G. Barbour, acting assistant. | Occupation of stations in continuation of the triangulation of the State of Vermont. |
| | 9 | Special triangulation. | Henry L. Whiting, assistant, and commissioner for the State of Massachusetts; Gershom Bradford, assistant; F. W. Perkins, assistant; C. H. Van Orden, subassistant. | Trigonometrical operations in aid of a topographical survey of the State of Massachusetts. |
| | 10 | Hydrographic examinations. | Lieut. Commander W. H. Brownson, U. S. N., assistant; Lieut. F. H. Crosby, U. S. N.; Ensigns P. J. Werlich, William Truxtun, E. Simpson, jr. and M. C. Gorgas, U. S. N. | Coasts of Massachusetts and Rhode Island (See also Section II.) |
| | 11 | Magnetic observations. | James B. Baylor, subassistant..... | Magnetic stations at Providence and on Coasters Harbor Island. (See also Section II.) |
| | 12 | Hydrographic examinations. | Ensign A. F. Fechteler, U. S. N., assistant; Ensigns F. W. Kellogg, and F. R. Brainard, U. S. N. | In the approaches to Newport, R. I. (See also Sections II and III.) |
| | 13 | Tidal observations | ................................... | Observations continued at Providence, R. I., with a self-registering tide-gauge loaned to the city engineer. |

APPENDIX No. 1—Continued.

| Sections. | Parties. | Operations. | Persons conducting operations. | Localities of work. |
|---|---|---|---|---|
| SECTION II. | | | | |
| Connecticut, New York, New Jersey, Pennsylvania, and Delaware, including coast, bays, and rivers. | No. 1 | Topography | Charles Hosmer, assistant; W. I. Vinal, subassistant. | Topographical resurvey of the northeastern coast of Long Island in the vicinity of Gardiner's Bay, Shelter Island, and Greenport; also of the north shore of the Sound from Darien, Conn., northward. |
| | 2 | Topography | W. I. Vinal, subassistant | Continuation of the topographical resurvey of the north shore of Long Island to the west of Greenport. |
| | 3 | Hydrographic examinations. | Ensign A. F. Fechteler, U. S. N., assistant; Ensigns F. W. Kellogg and F. R. Brainard, U. S. N. | Hydrographic work off Terry Point and Rocky and Horton's Points, Long Island. (See also Sections I and III.) |
| | 4 | Topography | W. C. Hodgkins, subassistant | Topographical resurveys at the mouth of the Connecticut River, and near Milford and Stratford, on the north shore of Long Island Sound; also from Lloyd's Neck eastward, on the south shore. |
| | 5 | Topography | W. H. Dennis, assistant; C. H. Van Orden, subassistant; J. W. Dudley, acting aid. | Continuation of the topographical resurvey of the north shore of Long Island Sound in the vicinity of Madison, Guilford, and Branford, Conn. |
| | 6 | Hydrography | Lieut. W. G. Cutler, U. S. N., assistant; Ensigns F. H. Sherman and J. S. Watters, U. S. N. | Inshore hydrographic survey of the northern coast of Long Island Sound from Hammonasset Point to Welch's Point. |
| | 7 | Tidal observations | | Tidal observations with an automatic gauge at the light-house on the New Haven Breakwater. |
| | 8 | Topography | E. Hergesheimer, assistant | Continuation of the topographic resurvey of the north shore of Long Island Sound from Frost (or Farms) Point westward. Topographical resurvey of shores of East River. |
| | 9 | Triangulation | Gershom Bradford, assistant | Triangulation in the western part of Long Island Sound extended from Lloyd's Neck towards New Rochelle. (See also Section I.) |
| | 10 | Topography | Charles Hosmer, assistant | Topographical resurvey of the north shore of Long Island Sound continued from Darien, Conn., towards New Rochelle, N. Y. |
| | 11 | Topography | E. Hergesheimer, assistant | Topographical resurvey of the shores of East River, New York. |
| | 12 | Hydrography | Lieut. J. M. Hawley, U. S. N., assistant. | Hydrographic resurvey of the East River, New York. |
| | 13 | Triangulation | E. F. Dickins, assistant | Determination of points for the resurvey of New York Lower Bay. |
| | 14 | Topography | J. Hergesheimer, assistant | Topographic resurvey of the shore lines of Coney Island and Rockaway Beach, New York lower bay. (See also Section VI.) |
| | 15 | Hydrography | Lieut. G. C. Hanus, U.S. N., assistant. | Hydrographic resurvey of the entrance to New York Bay. (See also Sections V and VI.) |
| | 16 | Topography | D. B. Wainwright, assistant | Topographic resurvey of the shores of the North River, New York. (See also Section III.) |
| | 17 | Hydrography | Lieut. W. G. Cutler, U. S. N., assistant. | Hydrographic resurvey of the North River, New York. |
| | 18 | Physical hydrography. | Henry Mitchell, assistant; H. L. Marindin, assistant; Marcus Baker, assistant. | Development of plans for the study of the physical hydrography of New York Bay and Harbor. |
| | 19 | Tidal observations | | Records of observations with self-registering tide-gauges at Governor's Island and at Sandy Hook. |
| | 20 | Topography | E. L. Taney, aid | Topographical resurvey of Sandy Hook. |
| | 21 | Geodetic operations. | Prof. E. A. Bowser, acting assistant. | Extension of reconnaissance and triangulation in the southern part of the State of New Jersey. |
| | 22 | Geodetic operations. | Prof. Mansfield Merriman, acting assistant; O. H. Tittmann, assistant. | Extension of reconnaissance and triangulation in the eastern half of the State of Pennsylvania. |

## APPENDIX No. 1—Continued.

| Sections. | Parties. | Operations. | Persons conducting operations. | Localities of work. |
|---|---|---|---|---|
| SECTION II—Continued. | No. 23 | Geodetic operations. | Prof. L. H. Barnard, acting assistant. | Reconnaissance for triangulation in the western half of the State of Pennsylvania. |
| | 24 | Triangulation .... | Spencer C. McCorkle, assistant; C. H. Sinclair, assistant; C. H. Van Orden, subassistant. | Special triangulation for the city of Philadelphia. |
| | 25 | Physical hydrography. | Henry Mitchell, assistant; Henry L. Marindin, assistant. | Physical hydrography of Delaware River and Bay. |
| | 26 | Triangulation .... | F. W. Perkins, assistant; C. H. Van Orden, subassistant. | Special triangulation. Delaware River, from Petty's Island to Poquessink Creek. (See also Section VIII.) |
| | 27 | Magnetic observations. | Edwin Smith, assistant .......... | Magnetic observations at Philadelphia. (See also Sections VIII, IX, and XV.) |
| | 28 | Hydrographic examinations. | Lieut. Commander W. H. Brownson, U. S. N., assistant; Ensign M. C. Gorgas, U. S. N. | Determination of position of wreck off Barnegat. (See also Section I.) |
| | 29 | Triangulation, reconnaissance, and magnetic observations. Continuation of topographic survey. | C. M. Bache, assistant; J. B. Baylor, subassistant. | Continuation of triangulation and reconnaissance on the New Jersey coast. Magnetic station occupied on that coast, and topographic survey continued. |
| | 30 | Topography ...... | R. M. Bache, assistant; E. L. Taney, aid. | Topographical resurvey of the New Jersey shore of Delaware Bay continued. |
| | 31 | Topography ...... | C. T. Iardella, assistant............ | Completion of the topographical resurvey of the western shore of Delaware Bay. |
| | 32 | Hydrography..... | Lieut. G. C. Hanus, U. S. N., assistant; Ensigns A. L. Hall, J. H. Hetherington, E. F. Leiper, and G. R. French, U. S. N. | Continuation of the hydrographic resurvey of Delaware entrance. (See also Sections V and VI.) |
| SECTION III. Maryland, District of Columbia, Virginia, and West Virginia, including bays, seaports, and rivers. | No. 1 | Determinations of gravity. | C. S. Peirce, assistant ............. F. H. Parsons, subassistant. | Gravity determinations and experimental researches at Washington, D. C., and in Virginia. (See also Section VI.) |
| | 2 | Magnetic observations. | Charles A. Schott, assistant.... .. | Annual determination of the magnetic declination, dip and intensity at a station on Capitol Hill, Washington. |
| | 3 | Topography ...... | John W. Donn, assistant; D. B. Wainwright, assistant. | Continuation of the detailed topographical survey of the District of Columbia. |
| | 4 | Geodesic leveling. | John B. Weir, assistant; John Nelson, aid. | Lines of leveling of precision carried from Ashland, Va., to Fortress Monroe. (See also Section XIV.) |
| | 5 | Special survey.... | Charles Junken, acting assistant. | Determination of points on the boundary line between Maryland and Virginia. |
| | 6 | Hydrographic examinations. | Ensign A. F. Fechteler, U. S. N., assistant. | Hydrographic examinations off Cape Henry, Va. (See also Sections I and II.) |
| | 7 | Topography ...... | Eugene Ellicott, assistant......... | Supplementary topographical survey between Norfolk and the ocean shore. (See also Sections I and VI.) |
| | 8 | Reconnaissance and triangulation. | A. T. Mosman, assistant; F. D. Granger, assistant; Prof. J. H. Gore, volunteer assistant; W. B. Fairfield, extra observer; J. E. McGrath, aid. | Extension of the primary triangulation near the thirty-ninth parallel from West Virginia into Kentucky and Ohio. |
| SECTION V. South Carolina and Georgia, including coast, sea-water channels, sounds, harbors and rivers. | No. 1 | Hydrography..... | Lieut. G. C. Hanus, U. S. N., assistant; Ensigns E. F. Leiper, F. R. Brainard and George R. French, U. S. N. | Hydrographic survey in Stono and Wadmelaw Rivers, South Carolina. (See also Sections II and VI.) |

## APPENDIX No. 1—Continued.

| Sections. | Parties. | Operations. | Persons conducting operations. | Localities of work. |
|---|---|---|---|---|
| SECTION VI. | | | | |
| Peninsula of Florida, from Saint Mary's River, on the east coast, to and including the Anclote Keys on the west coast, with the coast approaches, reefs, keys, seaports and rivers. | No. 1 | Triangulation and topography. | Eugene Ellicott, assistant | Triangulation and shore-line topography of Saint John's River from Palatka to Nine-mile Point. (See also Sections I and III.) |
| | 2 | Hydrography | Lieut. G. C. Hanus, U. S. N., assistant; Ensign E. F. Leiper, U. S. N., assistant; Ensigns F. R. Brainard and G. R. French, U. S. N. | Hydrographic survey of Saint John's River from Racy Point to Palatka. (See also Sections II and V.) |
| | 3 | Physical hydrography. | Lieut. J. E. Pillsbury, U. S. N., assistant; Ensigns A. F. Fechteler, P. J. Werlich, W. A. Thom, William Truxtun, E. Simpson, and M. C. Gorgas, U. S. N. | Deep sea soundings in N. W. Providence Channel, and in Gulf Stream off Florida coast, and subcurrent observations in Gulf Stream between Fowey Rocks and Gun Cay, Bahamas. (See also Section I.) |
| | 4 | Determination of gravity. | C. S. Peirce, assistant; W. B. Fairfield, extra observer. | Determination of gravity at Key West. (See also Section III.) |
| | 5 | Beach measure and topography. | Joseph Hergesheimer, assistant; J. H. Turner, aid. | Beach measure and topography on west coast of Florida from Bowditch Point to Cape Romano. (See also Section II.) |
| | 6 | Hydrography | Lieut. E. D. F. Heald, U. S. N., assistant; Ensigns T. D. Griffin, J. M. Orchard, A. Jeffries, W. C. Canfield, and J. E. Craven, U. S. N. | Hydrographic survey of the west coast of Florida from the vicinity of Gordon's Pass to Cape Romano. (See also Sections I and VIII.) |
| SECTION VIII. | | | | |
| Alabama, Mississippi, Louisiana, and Arkansas, including Gulf coasts, ports, and rivers. | No. 1 | Reconnaissance | O. H. Tittmann, assistant; George F. Bird, aid. | Continuation of reconnaissance for the connection of the triangulation of the Gulf coast with that along the Blue Ridge. (See also Section II.) |
| | 2 | Hydrography | Lieut. E. D. F. Heald, U. S. N., assistant; Ensigns T. D. Griffin, J. M. Orchard, A. Jeffries, W. C. Canfield, and J. E. Craven, U. S. N. | Hydrographic work in Mobile Bay and around the Chandeleur Islands. (See also Sections I and VI.) |
| | 3 | Telegraphic longitudes. | Edwin Smith, assistant; C. H. Sinclair, assistant; E. D. Preston, subassistant. | Determination of the longitudes of Little Rock, Texarkana, and Fort Smith, Arkansas. (See also Sections IX, XV, and XVI.) |
| | 4 | Triangulation and topography. | F. W. Perkins, assistant, E. L. Taney, aid; Richard C. Wilson, volunteer aid. | Triangulation and topography of the coast of Louisiana from Coté Blanche Bay to the westward. (See also Section I.) |
| | 5 | Hydrography | Lieut. F. H. Crosby, U. S. N., assistant; Ensigns T. M. Brumby, A. L. Hall, J. H. Hetherington, and J. S. Watters, U. S. N. | Hydrographic survey off the coast of Louisiana from Sabine Pass eastward. |
| SECTION IX. | | | | |
| Texas and Indian Territory, including Gulf coast, bays, and rivers. | No. 1 | Telegraphic longitudes. | Edwin Smith, assistant; E. D. Preston, subassistant. | Determination of the longitude of Brownsville Texas. (See also Sections VIII, XV, and XVI.) |
| | 2 | Triangulation | R. E. Halter, assistant | Triangulation and wire-measurement between Point Isabel and Brownsville, Texas. |
| SECTION X. | | | | |
| California, including the coast, bays, harbors, and rivers. | No. 1 | Triangulation | A. F. Rodgers, assistant | Survey of the coast-line, connecting the work at San Juan Capistrano with that at Newport Bay. |
| | 2 | Magnetic observations. | Marcus Baker, assistant; Carlisle Terry, jr., aid. | Series of observations continued at the magnetic self-registering record station at Los Angeles, Cal. |

## APPENDIX No. 1—Continued.

| Sections. | Parties. | Operations. | Persons conducting operations. | Localities of work. |
|---|---|---|---|---|
| SECTION X—Continued. | No. 3 | Triangulation .... | James S. Lawson, assistant; P. A. Welker, aid. | Continuation of the primary triangulation of the coast of California north of Point Concepcion. |
| | 4 | Triangulation and topography. | Stehman Forney, assistant ...... | Survey of the coast of California continued from Moro Bay eastward. |
| | 5 | Hydrography..... | Lieut. E. D. Taussig, U. S. N., assistant; Lieut. F. H. Lefavor, U. S. N.; Ensigns W. L. Burdick and P. B. Bibb, U. S. N. | Hydrographic survey of the California coast in the vicinity of San Simeon. |
| | 6 | Triangulation .... | George Davidson, assistant; R. A. Marr, subassistant; Fremont Morse, aid; C. B. Hill, acting aid. | Occupation of stations in continuation of the primary triangulation of the coast of California. |
| | 7 | Tidal observations | E. Gray, tidal observer............ | Self-registering tide-gauge record kept up at Saucelito, San Francisco Bay. |
| | 8 | Hydrography ..... | Lieut. E. D. Taussig, U. S. N., assistant; Ensigns J. N. Jordan, W. L. Burdick, J. A. Bell, and F. A. McNutt, U. S. N. | Hydrographic surveys on the California coast in Humboldt Bay and between Brushy Point and White Rock. |
| SECTION XI. | | | | |
| Oregon and Washington Territory, including coast, interior bays, ports, and rivers. | No. 1 | Triangulation and topography. | Louis A. Sengteller, assistant..... | Survey of the Umpquah River, Oregon. |
| | 2 | Topography and hydrography. | Cleveland Rockwell, assistant.... | Continuation of the topographical survey of the Columbia and Willamette Rivers. Hydrography of the Willamette River. |
| | 3 | Topography and reconnaissance. | J. J. Gilbert, assistant............ | Completion of the topography of Hood's Canal, W. T. Reconnaissance of the Olympic Mountains. |
| | 4 | Hydrography..... | Lieut. C. F. Forse U. S. N., assistant; Ensign J. N. Jordan, U. S. N., assistant. | Hydrographic surveys in Hood's Canal, W. T. |
| | 5 | Triangulation and topography. | J. F. Pratt, assistant............ | Triangulation and topography of Possession Strait and Sound, W. T. |
| | 6 | Reconnaissance and triangulation. | B. A. Colonna, assistant; J. F. Pratt, assistant. | Reconnaissance for the triangulation of the Strait of Fuca. |
| | 7 | Hydrography. | Lieut. Commander A. S. Snow, U. S. N., assistant; Lieut. G. Blocklinger, U. S. N.; Ensigns W. V. Bronaugh, F. M. Bostwick, and W. P. White, U. S. N. | Hydrographic survey of the Strait of Fuca. |
| SECTION XII. | | | | |
| Alaska, including the coast and the Aleutian Islands. | No. 1 | Hydrography..... | Lieut. Richardson Clover, U. S. N., assistant; Ensigns W. McLean, C. C. Marsh, D. P. Menefee, T. G. Dewey, and A. P. Niblack, U. S. N. | Hydrographic surveys in Southeastern Alaska. |
| | 2 | Tidal observations | W. J. Fisher and F. Sargent..... | Tidal observations continued with self-registering tide-gauge at Saint Paul, Kadiak Island, Alaska. |
| SECTION XIII. | | | | |
| Kentucky and Tennessee.. | No. 1 | Reconnaissance and triangulation. | A. T. Mosman, assistant; J. E. McGrath, aid. | Reconnaissance for extending the primary triangulation near the 39th parallel from West Virginia into Kentucky and Ohio. |
| | 2 | Geodetic operations. | Prof. A. R. Buchanan, acting assistant. | Occupation of stations in continuation of the triangulation of the State of Tennessee. |
| SECTION XIV. | | | | |
| Ohio, Indiana, Illinois, Michigan, and Wisconsin. | No. 1 | Reconnaissance and triangulation. | A. T. Mosman, assistant; J. E. McGrath, aid. | Reconnaissance for extending the primary triangulation near the 39th parallel into Ohio and Kentucky. |

## APPENDIX No. 1—Continued.

| Sections. | Parties. | Operations. | Persons conducting operations. | Localities of work. |
|---|---|---|---|---|
| SECTION XIV—Continued. | No. 2 | Geodetic operations. | Prof. R. S. Devol, acting assistant | Continuation of the triangulation of the State of Ohio. |
| | 3 | Geodetic operations. | Prof. J. L. Campbell, acting assistant; Prof. J. M. Coulter, recorder. | Occupation of stations in continuation of the triangulation of the State of Indiana. |
| | 4 | Triangulation | George A. Fairfield, assistant; J. S. Bradford, assistant; J. B. Boutelle, extra observer; F. B. Bacon, recorder. | Extension of the primary triangulation near the 39th parallel eastward across the State of Illinois. |
| | 5 | Geodesic leveling. | John B. Weir, assistant; John Nelson, aid. | Progress made in connecting the line of transcontinental leveling with a point on the Gulf coast. |
| | 6 | Geodetic operations. | Prof. J. E. Davies, acting assistant | Occupation of stations in continuation of the triangulation of the State of Wisconsin. |
| SECTION XV. | | | | |
| Missouri, Kansas, Iowa, Nebraska, Minnesota, and Dakota. | No. 1 | Triangulation | F. D. Granger, assistant | Occupation of stations for continuing to the westward the primary triangulation near the 39th parallel in Missouri and Kansas. |
| | 2 | Telegraphic longitudes. | Edwin Smith, assistant; C. H. Sinclair, assistant. | Determination of the longitude of Kansas City, Mo. |
| SECTION XVI. | | | | |
| Nevada, Utah, Colorado, Arizona, and New Mexico. | No. 1 | Reconnaissance and triangulation. | William Eimbeck, assistant; G. F. Bird, aid. | Continuation of reconnaissance and triangulation in Utah near the 39th parallel. |
| SPECIAL OPERATIONS. | | Examination of methods of observation and photographic processes employed at the Magnetic Observatory, Toronto, Canada. | Marcus Baker, assistant | |
| | | Reports in regard to the suboffices at Boston, New York, and Philadelphia. | Henry Mitchell, assistant; F. J. Palmer, acting assistant; S. C. McCorkle, assistant. | |
| | | Charge of the exhibit of the Coast and Geodetic Survey at the New Orleans Exposition. | George W. Dean, assistant; C. H. Boyd, assistant; J. J. Clark, mechanician. | |
| | | Voyage of the new steamer C. P. Patterson from the Atlantic to the Pacific coast. | Lieut. Richardson Clover, U.S.N., assistant. | |
| | | Tidal observations at Honolulu, Sandwich Islands. | Superintendent of Hawaiian Government Survey. | |

# APPENDIX No. 2.

*Statistics of field and office work of the Coast and Geodetic Survey for the year ending June 30, 1885.*

| | Total to June 30, 1884. | Total during fiscal year. | Total to June 30, 1885. |
|---|---|---|---|
| RECONNAISSANCE. | | | |
| Area in square statute miles | 331 100 | 46 860 | 377 960 |
| Parties, number of | ........ | 4 | ........ |
| BASE LINES. | | | |
| Primary, number of | 14 | 0 | 14 |
| Primary, length in statute miles | 90 | 0 | 90 |
| Subordinate, number of | 129 | 1 | 130 |
| Subordinate and beach measures, length of | 442 | 34 | 476 |
| TRIANGULATION. | | | |
| Area in square statute miles | 193 420 | 6 444 | 199 864 |
| Stations occupied for horizontal measures, number of | 10 698 | 382 | 11 080 |
| Geographical positions determined, number of | 20 478 | 627 | 21 105 |
| Stations occupied for vertical measures, number of | 682 | 80 | 762 |
| Elevations determined trigonometrically, number of | 1 783 | 132 | 1 915 |
| Heights of benchmarks by spirit-leveling, number of | 2 689 | 325 | 3 014 |
| Lines of spirit-leveling, length of, in statute miles | 2 933 | 397 | 3 330 |
| Triangulation and leveling parties, number of | ........ | 30 | ........ |
| ASTRONOMICAL WORK. | | | |
| Azimuth stations, number of | 187 | 3 | 190 |
| Latitude stations, number of | 312 | 6 | 318 |
| Longitude stations, telegraphic, number of | 124 | 3 | 127 |
| Longitude stations, chronometric or lunar, number of | 110 | 0 | 110 |
| Astronomical parties, number of | ........ | 6 | ........ |
| MAGNETIC WORK. | | | |
| Stations occupied, number of | 675 | 18 | 693 |
| Permanent magnetic stations, number of | ........ | 2 | ........ |
| Magnetic parties, number of | ........ | 7 | ........ |
| TOPOGRAPHY. | | | |
| Area surveyed, in square statute miles | 29 134 | 1 147 | 30 281 |
| Length of general coast in statute miles | 6 728 | 14 | 6 742 |
| Length of shore-line, in statute miles, including rivers, creeks, and ponds | 84 510 | 1 995 | 86 505 |
| Length of roads, in statute miles | 42 423 | 1 829 | 44 252 |
| Topographical parties, number of | ........ | 25 | ........ |
| HYDROGRAPHY. | | | |
| Parties, number of | ........ | 15 | ........ |
| Number of miles (geographical) run while sounding | 369 415 | 8 810 | 378 225 |
| Area sounded, in square geographical miles | 95 335 | 4 245 | 99 580 |
| Miles run, additional of outside or deep-sea soundings | 74 748 | 508 | 75 256 |
| Number of soundings | 16 684 410 | 322 918 | 17 007 328 |
| Deep-sea soundings | 12 936 | 154 | 13 090 |
| Deep-sea temperature observations | 11 801 | 209 | 12 010 |
| Current stations, number of | 615 | ........ | ........ |
| Deep-sea current stations, number of | ........ | 17 | ........ |
| Deep-sea sub-current observations, number of | ........ | 1 059 | ........ |
| Deep-sea surface current observations, number of | ........ | 2 326 | ........ |

## APPENDIX No. 2—Continued.

| | Total to June 30, 1884. | Total during fiscal year. | Total to June 30, 1885. |
|---|---|---|---|
| HYDROGRAPHY—Continued. | | | |
| Specimens of bottom, number of | 12 338 | 290 | 12 628 |
| Automatic tide gauges established* | 82 | 3 | 85 |
| Automatic tide gauges discontinued* | 78 | 1 | 79 |
| Staff and box gauges established* | 1 610 | 34 | 1 644 |
| Staff and box gauges discontinued* | 1 606 | 33 | 1 639 |
| Parties doing tidal work exclusively* | .......... | 4 | .......... |
| Parties doing tidal in connection with hydrographic work* | .......... | 18 | .......... |
| RECORDS. | | | |
| Triangulation, originals, number of volumes | 4 305 | 277 | 4 582 |
| Astronomical observations, originals, number of volumes | 1 738 | 59 | 1 797 |
| Magnetic observations, originals, number of volumes | 563 | 64 | 627 |
| Duplicates of above, number of volumes | 4 547 | 370 | 4 917 |
| Computations, number of volumes | 3 819 | 156 | 3 975 |
| Hydrographic soundings and angles, originals, number of volumes | 9 020 | 302 | 9 322 |
| Hydrographic soundings and angles, duplicates, number of volumes | 1 895 | 280 | 2 175 |
| Tidal and current observations, originals, number of volumes | 3 592 | 94 | 3 686 |
| Tidal and current observations, duplicates, number of volumes | 2 346 | 56 | 2 402 |
| Aggregate years of record from automatic tide gauges* | 246 | 5 | 251 |
| Tidal stations for which reductions have been made* | 929 | 36 | 965 |
| Aggregate years of record reduced* | 204 | 4 | 208 |
| MAPS AND CHARTS. | | | |
| Topographic maps, originals | 1 669 | 9 | 1 678 |
| Hydrographic charts, originals | 1 759 | 58 | 1 817 |
| Reductions from original sheets | 945 | 17 | 962 |
| Total number of manuscript maps and charts | 2 706 | 19 | 2 725 |
| Number of sketches made in field and office | 3 246 | 36 | 3 282 |
| ENGRAVING AND PRINTING. | | | |
| Engraved plates of finished charts, number of | 274 | 11 | 285 |
| Engraved plates of preliminary charts, sketches and diagrams for the Coast and Geodetic Survey reports, number of | 650 | 1 | 651 |
| Electrotype plates made | 1 758 | 66 | 1 824 |
| Finished charts published | 408 | 11 | 419 |
| Engraved plates of Coast Pilot charts | 77 | 3 | 80 |
| Engraved plates of Coast Pilot views | 88 | 1 | 89 |
| Printed sheets of maps and charts distributed | 549 425 | 14 870 | 564 295 |
| Printed sheets of maps and charts deposited with sale agents | 229 480 | 14 035 | 243 515 |
| Charts published by photolithography | .......... | 16 | .......... |

* The form in which tidal statistics have been presented in preceding reports is here superseded by one, which, although it shows no diminution in the amount of field work done, is believed to exhibit that amount more distinctly, and to be much less liable to erroneous interpretation. An additional entry, requisite to complete the exhibit, is omitted this year for lack of time for its preparation.

# APPENDIX No. 3.

*Information furnished to Departments of the Government in reply to special requests, and to individuals upon application,* during the fiscal year ending June 30, 1885.*

| Date. | | Name. | Data furnished. |
|---|---|---|---|
| 1884. | | | |
| July | 2 | John Tatlock, jr., Assistant Astronomer, Madison, Wis | Six geographical positions determined by Coast and Geodetic Survey at Beloit, Wis. |
| | 12 | Randolph Keim, Washington, D. C | Distance and direction of Sugarloaf Mountain, Md., from the Washington Monument. |
| | 15 | Chief of Engineers, U. S. A | On the tides at Galveston, Tex. |
| | 17 | Lieut. P. H. Ray, U. S. A., Signal Service | Copy of report on the discussion of his tidal observations at Ooglaamie, near Point Barrow, Alaska. |
| | 17 | Director U. S. Geological Survey | Geographical positions in Northwest Georgia and Northeast Alabama and heights; also positions of two astronomical stations in Kentucky, with descriptions. |
| | 19 | Director U. S. Geological Survey | Geographical positions of a number of points near the boundaries of Ohio, West Virginia, and Kentucky. |
| | 21 | General V. D. Groner, General, Agent Merchants' and Miners' Transportation Company, Norfolk, Va. | Topography sea-coast of Virginia from life-saving station "Seatack" to life-saving station "Dam Neck Mills," 1859. |
| | 25 | Horace S. Crowell, Boston, Mass | Topographical Survey West Island and vicinity, Buzzard's Bay, Mass., 1845. |
| | 25 | Director U. S. Geological Survey | Geographical positions near western boundary of Massachusetts, and of State House, Boston. |
| | 28 | Director U. S. Geological Survey | Geographical positions of fourteen stations in Northwest Georgia and Northeast Alabama. |
| | 29 | Director U. S. Geological Survey | Geographical positions of three stations in California. |
| | 31 | Maj. G. L. Gillespie, Engineer Corps, U. S. A | Bench-marks at Sandy Hook, N. J., for survey for deepening Gedney's Channel. |
| Aug. | 5 | Rudolph Hering, Assistant Engineer, Philadelphia Water Department. | Geographical positions, and geodetic and magnetic data for three triangulation stations. |
| | 6 | Director U. S. Geological Survey | Positions of astronomical stations in Missouri and Kansas, with descriptions. |
| | 6 | Maj. G. L. Gillespie, Engineer Corps, U. S. A | Geographical positions on lower New York Bay and vicinity. |
| | 6 | P. B. Wood, Surveyor, Peshtigo, Wis | Geographical positions of stations in the vicinity of Peshtigo and data for secular change of the declination. |
| | 7 | Maj. G. L. Gillespie, Engineer Corps, U. S. A | Bench-marks around Raritan Bay, especially at Locust Grove Gravesend Bay. |
| | 12 | E. S. Holden, Director Astronomical Observatory, Madison, Wis. | Result for latitude of Coast Survey Station Madison from revised star places. |
| | 15 | Harbor Commission of Norfolk and Portsmouth | Part of East Branch Elizabeth River, Va., 1873 and 1882. |
| | 22 | Prof. A. Hall, U. S. Naval Observatory | Declination of nine stars used for determination of latitude. |
| | 26 | Prof. J. Howard Gore, Columbian University | Information respecting certain statistics of, and recent progress in, geodesy on the Coast and Geodetic Survey. |
| | 27 | E. G. Butler, Henderson, Vance County, North Carolina | Variation in the magnetic declination at Henderson between 1800 and 1885. |
| | 28 | Jacob W. Rand, Surveyor, Vanceburg, Ky | Information respecting magnetic declination at that place. |
| | 30 | O. F. Horner, New Egypt, N. J | Results of magnetic investigations. |
| Sept. | 6 | W. S. Summers, Charleston, W. Va | Latitude and longitude of astronomical station at Charleston. |
| | 6 | General William Birney, Washington, D. C | Copy of survey of Ashepoo River near mouth of Mosquito Creek, S. C. |

*Tracings from topographic or hydrographic sheets, transcripts of unpublished results of the work, and other data, when supplied for private use, are furnished upon payment of the cost of preparation in the office.

## APPENDIX No. 3—Continued.

| Date. | | Name. | Data furnished. |
|---|---|---|---|
| 1884. | | | |
| Sept. | 12 | Capt. F. A. Hinman, Engineer Corps | Hydrographic survey of South Branch, Elizabeth River, Va. |
| | 13 | D. B. Wellman, Assistant U. S. Engineer, Saint Louis, Mo. | Geodetic data of six trigonometrical stations on the Missouri River. |
| | 15 | H. A. Wise, Superintendent Public Instruction, Baltimore | Table of magnetic declination at Baltimore 1810 to 1885 and information of position of agonic line at present and in former centuries. |
| | 16 | M. A. Miller, Engineer, Oceana, Wyoming County, W. Va | Rate of change of magnetic declination in West Virginia and position of agonic line at present. |
| | 17 | International Electric Exhibition, Philadelphia, Prof. Snyder. | Determination of the magnetic dip, horizontal and total intensity at the test laboratory of the exhibition. |
| | 18 | James L. Bryan, Secretary of Board of School Commissioners, Cambridge, Md. | Information about secular variation of the magnetic declination at Cambridge, Md., and declination at present. |
| | 18 | Maj. C. W. Raymond, Engineer Corps, U. S. A | Geodetic data about Providence, Cape Cod; position of twenty trigonometrical points. |
| | 22 | Maj. G. L. Gillespie, Engineer Corps, U. S. A | Hydrographic survey of eastern part of Hempstead Bay, L. I., New York, 1880. |
| Oct. | 1 | E. D. Ficklin, Fairfax Court House, Va | Magnetic declination at Fairfax since 1820. |
| | 2 | D. C. Sanford, South Norwalk, Conn | Magnetic declination off Westport, Conn. |
| | 3 | Emil Mayer, Munich, Germany | Compiled tracing of Mississippi River Delta and adjacent coast, together with unfinished proof of Coast Chart No. 94, 1-80000. |
| | 7 | Thomas D. Davis, Lynchburg, Va | Geographical position of Lynchburg. |
| | 11 | Maj. C. W. Raymond, Engineer Corps, U. S. A | Comparative map of the extremity of Cape Cod, Massachusetts, from the surveys of 1848 and 1857, and Commissioner's survey of 1867. |
| | 11 | S. G. Hilborn, U. S. District Attorney, San Francisco, Cal. | Topographic and hydrographic surveys of Mare Island and Napa Creek, and adjacent marsh lands. |
| | 13 | Maj. S. M. Mansfield, Engineer Corps, U. S. A., Galveston, Tex. | Unfinished proof of Coast Chart No. 110, Corpus Christi Bay. |
| | 14 | Director U. S. Geological Survey, Washington, D. C | Height above the sea of one hundred and twenty geographical positions in Massachusetts. |
| | 22 | G. H. Cook, State Geologist, New Jersey | Geodetic data of twenty-two trigonometrical points in New Jersey. |
| | 29 | Capt. William T. Rossell, Engineer Corps, U. S. A | Bench-marks at Tampa, Cedar Keys, Apalachicola Bay, and Key West. |
| | 30 | A. M. Ford, Atlantic City, N. J | About Tide Tables and the tides at Sandy Hook and Fernandina. |
| | 30 | Editor of Science, Cambridge, Mass | Records of self-registering tide-gauges at Saucelito, Cal., Kadiak, Alaska, and Honolulu. |
| Nov. | 4 | Director U. S. Geological Survey, Washington, D. C | Geographical positions in Kentucky near the boundary of West Virginia and Ohio. |
| | 5 | A. Foster Higgins, chairman of the Standing Committee of Harbor and Shipping, New York Chamber of Commerce. | Hydrographic survey of entrance to New York Harbor made in 1835, 1-10000. |
| | 6 | Prof. S. H. Pritchett, Saint Louis University | Telegraphic longitude of Saint Louis as determined in 1870 and 1881. |
| | 6 | J. P. Bogart, Engineer of the Connecticut Shellfish Commission. | Geographical position of Milford spire. |
| | 7 | Director U. S. Geological Survey, Washington, D. C | Angles to Standing Indian, N. C., from Rabun and Blood stations. |
| | 7 | Richard Lamb, Norfolk, Va | Information about methods for finding the true meridian with reference to magnetic meridian. |
| | 10 | Capt. F. V. Greene, Assistant Engineer Commissioner, District of Columbia. | Statistics of a number of primary, secondary, and tertiary triangulation stations in and around the District. |
| | 12 | J. P. Bogart, Engineer Connecticut Shellfish Commission | Topographical survey of west shore of New Haven Harbor, vicinity of Savin Rock, and Oyster River Point, 1872. |
| | 12 | William F. Smith | Relating to loan of tide-gauges for use in Delaware Bay. |
| | 12 | G. L. Vose, Boston Institute of Technology | Azimuth of line Blue Hill to Boston State House. |
| | 14 | A. Foster Higgins, chairman of the Standing Committee of Harbor and Shipping, New York Chamber of Commerce. | Diagram showing the progressive and retrograde changes of Sandy Hook Spit; also cross-section of main ship-channel to Flynn's Knoll. |
| | 17 | Mr. E. S. Philbrick, C. E., Boston, Mass | Hydrographic survey of Pocasset and Red Brook Harbors, Buzzard's Bay, Massachusetts. |
| | 20 | M. A. Miller, C. E., Staunton, Va | Geographical position of Ivy Station, West Virginia, and magnetic declinations in West Virginia. |
| | 21 | Prof. C. F. Osborne, Connell University, Ithaca, N. Y | Matters relating to the building of magnetic observatories. |
| | 24 | Lieut. M. M. Macomb, U. S. A., Fort Monroe, Virginia | Distance and direction from Old Point Comfort Light to Thimble Shoal Light. |
| | 24 | Capt. H. S. Taber, Engineer Corps, U. S. A., Little Rock, Ark. | Geographical position of Little Rock. |
| | 25 | General John Westcott, President Florida Canal Company. | Hydrographic survey Florida Passage, Jupiter Narrows to Jupiter Inlet. |

## APPENDIX No. 3—Continued.

| Date. | | Name. | Data furnished. |
|---|---|---|---|
| 1884. | | | |
| Dec. | 3 | A. J. Hill, Saint Paul, Minn | Length of a degree of the meridian in latitudes 43° to 49°; geographical position of Minneapolis, Minn., and information respecting local deflection of the plumb-line in the Eastern States. |
| | 6 | H. F. Walling, U. S. Geological Survey | Seven geodetic positions near southwest corner of Massachusetts. |
| | 6 | Lewis Pittman, Clearville, Pa | Secular variation of magnetic declination at Clearville between 1780 and 1885, with diagram. |
| | 9 | F. M. Drew, Attorney-at-Law, Lewiston, Me | Change in the direction of the magnetic needle at Leeds, Maine, between 1809 and 1884. |
| | 10 | E. H. Roberts, Utica Morning Herald and Gazette, Utica, N. Y. | Geographical data respecting the position of New York Bay. |
| | 10 | James Moylan, Engineer Atlantic and Pacific Railroad, Peach Springs, Ariz. | Geographical position of six places in New Mexico, Arizona, and California. |
| | 11 | Director U. S. Geological Survey | Geographical and geodetic information respecting stations in the vicinity of southwest corner of Massachusetts. |
| | 13 | Lieut. Fred. V. Abbot, Engineer Corps, U. S. A | Geodetic data, descriptions of stations, and sketch of triangulation vicinity of Fernandina, Fla., Saint Mary's, Ga., and Tiger Island, Fla. |
| | 15 | Director U. S. Geological Survey | Geodetic positions in the vicinity of Front Royal and Strasburg, Va. |
| | 17 | U. S. Light-House Board | Hydrographic survey L'Homme Dieu Shoal, Nantucket Sound. |
| | 17 | ......do | Hydrographic examination of shoal ground off Point Judith. |
| | 18 | Prof. Fairman Rogers | Hydrographic survey part of Cumberland Sound, Georgia. |
| | 22 | F. K. Hazen, Goffstown, N. H | Geographical positions of Manchester and Unkonoonuc. |
| | 23 | Hon. E. Moody Boynton, Newburyport, Mass | Hydrographic survey of Sabine and Calcasieu Passes and coast line between the same, with a map of Louisiana. |
| | 27 | G. L. Vose, Institute of Technology, Boston, Mass | Height of trigonometrical station at Blue Hill, Mass. |
| | 27 | Fauth & Co., mathematical-instrument makers, Washington. | Computation of length of four standard base bars. |
| 1885. | | | |
| Jan. | 8 | H. F. Walling, U. S. Geological Survey | Logarithmic ratio of Borden's linear measure to meter, and geographical position of Greylock and Saddle Mountains, Massachusetts. |
| | 9 | Director U. S. Geological Survey | Geographical positions and geodetic results of triangulation in Southern Tennessee, 1884 work. |
| | 9 | Director U. S. Geological Survey | Position of station Buffalo, Virginia, and description. |
| | 15 | James P. Bogart, Engineer Connecticut Shellfish Commission. | Hydrographic survey of Townsend's Ledge, off New Haven, 1872. |
| | 16 | George H. Cook, State Geologist, New Jersey | Geographical positions coast of New Jersey, between Goshen Creek and West Creek, and between Townsend's Inlet and Absecon Light. |
| | 16 | J. P. Winthringham, New York | Magnetic horizontal intensity at New York in dynes. |
| | 19 | Prof. Henry Mitchell, Boston, Mass., for friend | Mean high and low waters and bench-marks at Boston navy-yard. |
| | 22 | Albert Bayles, U. S. Engineer's Office | Bench-marks and tides at South Island, Winyah Bay, S. C. |
| | 22 | T. J. Henderson, Commissioner of Agriculture, Georgia | Geographical positions of five hundred and five points in Georgia. |
| | 22 | Van Antwerp, Bragg & Co., Cincinnati, Ohio | Geographical positions of Little Rock and Helena, Ark., and of Kansas City and Saint Louis, Mo., and Fort Smith, Ark. |
| | 23 | Capt. Charles F. Powell, U. S. Engineers, Portland, Oreg. | Bench-marks and tides in Budd's Inlet, Puget Sound, Washington Territory. |
| | 24 | H. F. Walling, U. S. Geological Survey | Description of two stations near the southwest corner of Massachusetts. |
| Feb. | 2 | C. G. Rupert, Yale College, New Haven, Conn | Information on geodesy. |
| | 2 | J. T. Kile, Upper Tract, Pendleton County, W. Va | Information on distribution of magnetic declination in the United States. |
| | 3 | L. Cutshaw, Denver, Colo | Determination of astronomical azimuth. |
| | 4 | G. de Weckherlin, Minister Plenipotentiary of the Netherlands. | Copy of earthquake waves as recorded on the self-registering tide-gauges at San Francisco, Alaska, and Sandwich Islands. |
| | 5 | A. W. Parker, Brooklyn, N. Y | Limits of marsh land in Hampstead and South Oyster Bays, Long Island, 1880. |
| | 7 | Dr. Henry J. Bigelow, 52 Beacon street, Boston, Mass | Topographic survey western part of Nantucket Island; vicinity of Tuckernuck Island, Massachusetts. |
| | 7 | Charles Hervey Townshend, New Haven, Conn | Sketch showing limits of resurvey of Long Island Sound, New York; also tides and tidal observations in New Haven Harbor. |
| | 7 | Topographer Post-Office Department | List of geographical positions in the States of New York, Vermont, California, and Nevada. |
| | 2 | David Porter, Custom-house, Savannah, Ga | Relating to the diurnal inequality in time, as given in the tide-tables for 1885. |

## APPENDIX No. 3—Continued.

| Date. | | Name. | Data furnished. |
|---|---|---|---|
| 1885. | | | |
| Feb. | 12 | S. Huston, Richmond, Ohio | Tables and charts of distribution of magnetic declination in the United States. |
| | 13 | D. A. Nash, Office Commissioners of Pilots, New York | Magnetic disturbed regions; vicinity of Long Island, and effect on compasses on board ship. |
| | 17 | M. L. Baxter, Derby Line, Vermont | Geographical position of Boundary station near Derby, and of Jay Rock, Vt. |
| | 19 | J. E. Laidler, Hawkinsville, Ga | Magnetic declination at Hawkinsville at present. |
| | 24 | F. C. Purdy, Skokomish, Mason County, W. T. | Instructions for magnetic observations and chart of distribution of the magnetic declination in 1885. |
| | 24 | G. R. Prowell, York, Pa | Three geographical positions determined by the survey in York County. |
| | 27 | W. H. Holmes, Philadelphia, Pa | Table of geographical positions in the city of Philadelphia. |
| Mar. | 2 | William Fears, Town Point, Cecil County, Md | Topographic and hydrographic survey of Mill Creek, Piankatank River, Virginia, 1869. |
| | 5 | F. H. Quin, Assistant Engineer, Chesapeake and Ohio Railroad, Richmond, Va. | Magnetic declination at Richmond between 1750 and 1885. |
| | 12 | M. W. Raneona | Publications of the Coast and Geodetic Survey on Terrestrial Magnetism. |
| | 13 | H. H. Moses, Superintendent Sewers, City Hall, Boston, Mass. | Height of tides at Boston on February 9 and 10, 1867. |
| | 16 | H. F. Payson, City Engineer's Office, Providence, R. I | Explanation of time used in the Tide Tables for 1885. |
| | 17 | Alfred P. Boller, C. E | Topographic and hydrographic survey of Arthur Kill and Staten Island Sound. |
| | 18 | United States Light-House Board | Wreck chart, San Francisco and approaches, 1-200000. |
| | 19 | C. H. Farley, Harbor Commissioner, Portland, Me | Hydrographic survey of Fore River, Portland Harbor, Maine. |
| | 23 | R. Hering, Philadelphia Water Department | Geographical position of station Topton and description of station. |
| | 23 | O. J. Klotz, President Association of Dominion Land Surveyors. | Copies of three of the latest pamphlets on Magnetic Declination—Dip and Intensity—1881 and 1882. |
| | 23 | D. Koppmann, Engineer Harbor and Land Commissioner's Office, Gloucester, Mass. | Seven geographical positions on Gloucester Harbor and descriptions of stations. |
| | 25 | M. Williams, Collector's Office, Stonington, Conn | Position of the magnetic pole at present. |
| | 25 | Capt. George H. Cook, Assistant Quartermaster, U. S. A. | Hydrographic survey of New Rochelle Harbor and vicinity, Long Island Sound, 1883. |
| | 27 | J. T. Gardiner, Director New York State Survey | Ninety-two geodetic positions in counties in the vicinity and north of New York City. |
| | 28 | W. L. Nicholson, Topographer Post-Office Department | Geographical positions in Missouri, Kansas, and Colorado. |
| | 30 | Hoyt, Fogg & Donham, Portland, Me | Predicted tides for Boston and Portland for 1886—Jan., Feb., Mar.—for Maine State Year Book. |
| | 31 | Director U. S. Geological Survey | Geodetic positions in Southeastern Massachusetts, determined in 1884. |
| Apr. | 4 | J. P. Bogart, Engineer Connecticut Shellfish Commission | Geographical positions of three stations Harbor of New Haven, Conn. |
| | 7 | J. P. Bogart, Engineer Connecticut Shellfish Commission | Distances and azimuths between three trigonometrical stations. |
| | 7 | William Smith, Deputy Minister of Marine, Ottawa, Canada. | Appendix No. 8, Report of 1876; also, a paper on "A Tide-gauge with Heating Apparatus," and a paper on observing currents. |
| | 8 | Silas Weeks, New Orleans, La | Topographic survey north shore Biloxi Bay, Mississippi Sound. |
| | 13 | L. M. Wright, Civil Engineer, Troy, N. Y | Secular variation of the magnetic declination at Troy, 1817 to 1885. |
| | 15 | H. T. Greenleaf, C. E., Elizabeth City, N. C | Secular change on Virginia and North Carolina boundary line of magnetic declination between 1728 and 1885. |
| | 15 | Director of U. S. Geological Survey | Geographical positions and descriptions of astronomical stations in Washington Territory and Oregon. |
| | 16 | Maj. Charles W. Raymond, Engineer Corps, U. S. A | Hydrographic survey mouth and bar of the Merrimac River, Massacusetts, 1851. |
| | 16 | United States Light-House Board | Hydrographic survey Anclote Bay, West Florida, 1884. |
| | 23 | J. T. Gardiner, Director New York State Survey | Descriptions of seventy-eight positions in Southern New York. |
| | 24 | J. H. Manzy, Rockingham County, Virginia | Data for re-running at present an old magnetic line. |
| | 25 | E. Deville, Surveyor-General, Dominion of Canada | Longitude of astronomical station Seattle, Washington Territory, and description of station. |
| | 25 | Director of U. S. Geological Survey | Abstract of horizontal directions of eight primary triangulation stations in Virginia and West Virginia. |
| May | 1 | Surgeon-General's Office | Times of high-waters at Chain Bridge, on the Potomac, on May 2, 1885. |
| | 2 | Lieut. G. L. Anderson, U. S. A., Philadelphia | Instructions for making magnetic observations. |
| | 2 | E. M. Scofield, Schenectady, N. Y | Pamphlet and chart of magnetic declination for 1885. |
| | 2 | T. W. Barally, Schenectady, N. Y | Pamphlet and chart of magnetic declination for 1885. |
| | 6 | A. W. Phillips, Yale College, New Haven, Conn | Pamphlet on distribution and secular change of magnetic declination, and directions for making magnetic observations. |

## APPENDIX No. 3—Continued.

| Date. | | Name. | Data furnished. |
|---|---|---|---|
| 1885. | | | |
| May | 15 | Director U. S. Geological Survey | Height of bench-marks and descriptions of stations, spirit-level line from Hagerstown, Md., to Alexandria, Va. |
| | 16 | Henry Seykes, New Haven, Conn | Length of Connecticut River in the States of New Hampshire, Massachusetts, and Connecticut. |
| | 19 | Postmaster, Harrisonville, Mo | Geographical position of Harrisonville. |
| | 20 | William C. Gunnell, Hampton, Va | Height of bench-mark of spirit-levels at Hampton, Va., above mean low water. |
| | 21 | R. Keith, Washington, D. C | Prediction of tides for Philadelphia for 1886, for Ledger Almanac. |
| | 22 | Director U. S. Geological Survey | Height above the sea of eight trigonometrical stations in West Virginia. |
| | 23 | A. M. Ford, Salem, N. J | Predictions for Atlantic Coast for 1886. Java earthquake waves. |
| | 25 | G. L. Osborne, President State Normal School, Warrensburg, Mo. | Geographical position and height of the Normal School. |
| | 26 | J. P. Little, Fernandina, Fla | Magnetic declination at Fernandina in 1831 and 1885 and annual change. |
| June | 1 | H. D. Cooke, Washington, D. C | Hydrography of inside passage between Saint Augustine and Mala Compra Creek, Florida. |
| | 1 | J. Francis Le Baron, C. E., Jacksonville, Fla | Hydrography west coast of Florida, Rocky Point to Long Boat Inlet, with unfinished proof, Coast Chart No. 76, 1-80000. |
| | 1 | G. H. Millman, Fort Meade, Polk County, Fla | Magnetic variation in Florida. |
| | 2 | Alfred Higbie, San Francisco, Cal | Distribution of magnetic declination in the United States and secular variation of the declination. |
| | 2 | Clement Manley, New Berne, N. C | Table of decimal values of the magnetic declination at New Berne since 1870. |
| | 3 | Charles E. Paine, C. E., Providence, R. I | Arrangement for testing compasses and laying out a meridional line. |
| | 3 | City Engineer, Providence, R. I | About the self-registering tide-gauge loaned by the Coast Survey to the city of Providence. |
| | 3 | Officer in Charge U. S. Engineer's office, Philadelphia, Pa. | About the self-registering tide-gauge at Fort Mifflin, belonging to the Coast Survey. |
| | 4 | S. D. Caldwell, Shade Gap, Huntington County, Pa | Three pamphlets from Coast and Geodetic Survey reports, bearing on the magnetic declination, especially in Pennsylvania. |
| | 6 | Director U. S. Geological Survey | Five principal geographical positions and descriptions of stations in Missouri. |
| | 6 | George Foeberry Lyster, Engineer, Liverpool, England. By request of James B. Eads, and for use in British Parliament. | General tidal curves for Governor's Island and Sandy Hook. |
| | 8 | George Foeberry Lyster, Engineer, Liverpool, England. | Diagrams of tides, for long series, at Sandy Hook and Governor's Island, N. Y. |
| | 10 | L. N. Christensen, Surveyor, Sand Hill, Marshall County, W. Va. | Magnetic declination at Wheeling. |
| | 10 | Prof. George H. Cook, State Geologist of New Jersey, New Brunswick, N. J. | Tidal bench-marks in and around Philadelphia, and matters connected therewith. |
| | 13 | Samuel M. Gray, C. E., Providence, R. I | Letter relating to observations of tides for 1878 to 1880. |
| | 16 | Director U. S. Geological Survey | Geographical positions in the vicinity of the Yolo Base, Cal., and geographical position of Austin, Tex. |
| | 19 | G. T. Wyer, Wellfleet, Mass | Magnetic declination at Wellfleet. |
| | 20 | F. Leonard, Pine Grove, Coxsackie, Greene County, N. Y. | Magnetic publications of the Coast and Geodetic Survey. |
| | 22 | C. A. McLeod, McGill Meteorological Observatory, Montreal, Canada. | Position of trigonometrical station on Mount Royal and of Cambridge Observatory. |
| | 23 | H. M. Robert, Lieutenant-Colonel Engineers, U. S. A | Geodetic positions vicinity of Marcus Hook, Delaware. |
| | 23 | U. S. Land Office | Shore line information, vicinity Mississippi Delta. |
| | 26 | C. A. McLeod, McGill College Observatory, Montreal, Canada. | Longitude of Chicago and Detroit and memoranda of references to Canadian longitudes. |
| | 26 | Maj. C. W. Raymond, Engineer Corps, U. S. A | Geographical positions in Boston Harbor. |
| | 26 | Director U. S. Geological Survey | Descriptions of ten principal triangulation stations in the vicinity of Sacramento, Cal. |
| | 26 | Prof. George H. Cook, State Geologist of New Jersey, New Brunswick, N. J. | Relating to tidal bench-marks around New Jersey. Descriptions of some furnished. |
| | 29 | Dwight Porter, Canton Center, Conn | Height of mean high-water above mean sea-level in Boston Harbor. |
| | 29 | City Clerk of Calais, Me | Topographic survey of Calais, Me., 1869. |
| | 29 | W. H. Chadbourn, jr., Wilmington, N. C | Magnetic declination in Columbus County, North Carolina. |
| | 29 | O. H. Tripp, Rockland, Me | Results of magnetic observations of the Coast and Geodetic Survey in Maine. |
| | 29 | W. C. Holbrook, County Surveyor, Coleta, Ill | Table of azimuth and time of elongation of Polaris and distribution of magnetic declination in Illinois. |
| | 30 | D. Köppmann, Engineer Harbor and Land Commissioner's Office, Massachusetts. | Positions of stations Railcut and Beacon Hill and distance and azimuth between them. |

## APPENDIX No. 4.

*REPORT OF THE ASSISTANT IN CHARGE OF OFFICE AND TOPOGRAPHY FOR THE YEAR ENDING JUNE 30, 1885.*

U. S. COAST AND GEODETIC SURVEY OFFICE,
*Washington, D. C., June* 30, 1885.

SIR: I have the honor to submit herewith my annual report from the Office, with the usual annual reports from each Division.

As in former years, the Computing Division, under the able management of Assistant C. A. Schott, has fully maintained its efficiency, all computations having been kept up to date, and a number of valuable reports submitted.

All calls for information have been promptly met, especially the unusually large number from the Office of the Geological Survey, and this notwithstanding the loss, by resignation, of Dr. J. G. Porter, one of the ablest computers, in September of last year, and the detachment of another computer for a considerable portion of the year. Mr. Schott has also found time to add still another mass of magnetic data to that already published, in the new tables of magnetic dips and intensities comprising some two thousand results, with a discussion of the secular variation and geographical distribution of these elements in the United States.

It is creditable to the growth and scientific development of the country that this class of information is more eagerly sought for than any other, despite its somewhat recondite character.

The Engraving, Electrotyping, and Printing Divisions have remained in charge of Assistant H. G. Ogden. The work of engraving new charts has, as during last year, given way to the more pressing necessity of making corrections to charts already published and largely used in navigation, where resurveys have developed important changes. Four hundred and twenty-one plates have been thus corrected.

Assistant Ogden urges an increase in the number of new charts to be printed and published by photolithography, that the results of our field surveys may be more promptly made available for public use. You are aware that this method has been pushed to the extreme limit possible with the present force in our Drawing Division.

The increase has been so rapid in excellence and in artistic merit in map-printing by this method that I have been disposed to submit to you a plan for a small addition to our force of draughtsmen, with a corresponding reduction elsewhere, in order to enable the Office to dispose more readily of the accumulating mass of data now on hand and continually coming in. A comparison of the newly published charts of New London Harbor and the Thames River, and also that of Newport, R. I., with other charts printed by photolithography two years ago will show the great change for the better to which I refer. The great diminution of cost is another reason for increasing this department of our work.

Improvements have been made in the batteries used in electrotyping, and a greater amount of work of a better character has been the result. These improvements have shown that it is not best to substitute a dynamo for the Smee and Walker batteries. A more uniform and regular deposit of copper has been obtained by the improved batteries upon the very large surfaces of our engraved plates than was had by the action of a dynamo.

The Printing Office has been rebuilt according to the original design, giving the printers more desirable quarters, with greater light and better air, while new presses of better quality have also been added. Much difficulty has been experienced since January last in keeping up our supply of paper of the proper quality and size. This, joined to the delay occasioned by putting up the new building, has rendered the whole number of charts printed during the year less than in the previous year. Arrangements have been concluded by which it is probable that a larger number will be produced and disposed of in future.

Mr. Ogden calls special attention to the able services of Mr. J. H. Smoot, Clerk of the Engraving Division.

The Tidal Division has remained in charge of Mr. R. S. Avery. It is hoped that the work in this division will be largely increased in efficiency during the ensuing year. The Tide Tables for the Atlantic and Pacific Coasts for 1886 are in the hands of the printer. In their preparation the "Tide Predictor," invented by Professor Ferrel, has been largely used.

An interesting incident of the year in this division has been the receipt from three widely separated tidal stations in the Pacific Ocean of the automatic records of the perturbations occasioned by the great Krakatoa earthquake of August 26, to September 2, 1883.

At the self-registering tide-gauges near San Francisco, Kadiak in Alaska, and Honolulu in the Sandwich Islands, the earthquake waves are sharply and distinctly recorded. This is especially the case at Honolulu. Photographic copies of the original records prepared in the Office have been forwarded to the Krakatoa Committee of the Royal Society at London by their request, and have also been printed in "Science" in this country. It is unfortunate that the self-registering tide-gauge, formerly maintained by the Coast and Geodetic Survey at Mazatlan, had been destroyed in one of the frequent attempts at revolution in that region. A similar automatic record of that place would have been of the highest service in estimating the time and force of this great earthquake wave in its progress over a space equal to more than one-third of the distance around the earth.

The Drawing Division has been actively employed during the entire year. In addition to its regular work, as set forth by Mr. Bright, it has furnished a large number of maps and tracings, specially called for by different branches of the Government and by private parties. Many of these have been of an elaborate character, requiring much time in their preparation.

In Appendix No. 3 is given a tabular statement of information furnished from this and other divisions of the Office in reply to official and unofficial requests.

A new feature introduced during the year has been the preparation of original topographic sheets for photolithographic printing in fac-simile. This has been very successful, the reproduced sheets showing great clearness in outline, with little or no distortion in scale. A combination of topographic and hydrographic original sheets upon a part of the Pacific Coast has also been tried at the instance of Assistant Davidson, and bids fair to be successful.

A re-organization of this Division, with a small addition to its force, as before suggested, will add largely to its efficiency.

Mr. M. W. Wines, General Office Assistant, has had charge of the Miscellaneous Division, and of all supplies to field parties of every kind of material needed by them, except instruments, as also of the distribution and sale of the publications of the survey. By his methodical manner of conducting these duties every field party has been promptly supplied, and much valuable time saved. His services to the Office in its relations with the Government Printing Office have contributed largely to the prompt publication of the Annual Reports.

The Office buildings, the Carpenter Shop, and the Map-mounting and Chart rooms have also been under his direction, as has been all communication with the Government Printing Office, and general supervision of all printing for the Coast and Geodetic Survey executed there. His duties have been laborious and responsible, and I owe him thanks for the thoroughness with which they have been attended to.

In the Instrument Division, under charge of Mr. G. N. Saegmuller, Chief Mechanician, much work has been done in repairs and remodeling of many instruments. Many old instruments have been regraduted and otherwise improved, and a large amount of miscellaneous work done. The addition made to the printing office involved the removal of the small testing observatory west of it, and a new and better one adjoining the Office of the Chief Mechanician has been erected in its place.

New instruments have been purchased as needed. All the apparatus which could be spared from use, including representative instruments in every department of our work, was put in thorough order during October and November, and sent to the New Orleans Exposition, in charge of Dr. J. J. Clark, adjuster in the Office of Construction of Standard Weights and Measures.

Improvements in this division are now planned and in process of execution which will give increased facilities and enable each person employed to do more work with greater ease to himself than has been heretofore possible, and the work-shops will then be more independent of outside aid. In these improvements I have had the skillful and ingenious assistance of Mr. Saegmuller.

A tabular statement will be found among the appendices to this report, giving in detail all information as to the number and classes of records added to the archives during the past year. The whole number of new volumes of records of observations, original and duplicate, is 1228. Up to March 31st the archives were in charge of Mr. R. M. Harvey.

At the close of the last fiscal year new projection tables, based upon the Clarke spheroid, and extending from the Equator to the Pole, were in course of preparation under my direction. These were completed and have now been printed, forming a book of 188 quarto pages, and being the most thorough and complete compilation ever printed upon this subject. While not free from error, it is hoped that these tables will prove to be more free from tabular errors than others before published. I am under obligations for faithful labor in this work to Sub-Assistants Baylor and McGrath, and to Mr. F. Morse, aid, who made the computations, and to Mr. McGrath and Miss S. C. Ayres, who prepared the tables for the printer, and read the proof. In this last most important matter I have also to acknowledge the great assistance rendered in the computing division by Assistant Schott and Mr. Doolittle, which added largely to the accuracy of the completed work.

The work of compilation of a map of the United States has made slow progress during the past year for lack of competent persons to continue it who could be spared from more pressing duties. But a large stock of material to be used in the work has been collected and brought to the office, ready for use as soon as opportunity offers.

At the commencement of the fiscal year, a measurement of all salt and fresh marsh land upon the Atlantic and Gulf Coasts had been undertaken at the request of the Commissioner of Agriculture. This was completed by Mr. A. Lindenkohl and Mr. McGrath, and the results communicated in tabular form. They have since been printed. The work was elaborate and laborious, occupying about three months.

After the middle of August, just as I hoped, with your permission to have a month of field-work, my principal Assistant, Mr. Henry W. Blair, was seized with typhoid fever and taken to Providence Hospital. His illness was very severe and lasted nearly three months. When able to leave the Hospital he went to his home in Lexington, Va., to complete his recovery, and there wrote a pamphlet giving a description of the principal instruments contained in the Coast and Geodetic Survey Exhibit at New Orleans, which was printed and circulated there. Having apparently recovered he started for New Orleans to take charge of the arrangement of the Exhibit and its display in the Government Building. But his recovery was not real, and on his way he was suddenly again prostrated, and died at Nashville of peritonitis on the 15th of December.*

Assistant Henry Wayne Blair was appointed upon the Coast Survey at my instance, as an aid in January, 1871. He was a graduate of the Virginia Military Institute, where his father, Col. William B. Blair, was a Professor. He was the first young gentleman from the South appointed upon the Survey after the war, being strongly recommended by General F. H. Smith, Superintendent of the Virginia Military Institute, and by General Henry C. Wayne and General Joseph E. Johnston, of Georgia. He was attached to my party, then in Georgia, and remained with me until 1877.

Of all the young men whom it has been my good fortune to train to become useful and efficient officers upon our work, no one has excelled him and but one has been his equal. Prompt, zealous, and untiring in field duty, he was equally useful in the Office, where his excellence as a close observer and mathematical reasoner procured him rapid promotion.

In 1875, at a competitive examination of twenty-three Aids, chosen from all the scientific institutions of the country, he came out at the head of the list.

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* A tribute to the memory of Mr. Blair appears in Appendix No. 18.

In all those traits of personal character which cause a man to be loved, respected, and honored among his comrades who best knew him, no one held a higher position, and no one is to-day more lamented.

To me, both personally and officially, his loss is irreparable. I loved him as a son, and leaned upon him as my Chief Assistant in the Office, to an extent I did not realize until his untimely death.

Assistant C. H. Sinclair was temporarily assigned by you to take Mr. Blair's place in the Office, and later Sub-Assistant F. H. Parsons was permanently assigned, and remained on duty with me until relieved, to return to field duty, being succeeded by Assistant B. A. Colonna. Mr. Parsons has been faithful and assiduous in the discharge of his duties, and I owe him thanks therefor.

During the year a larger number of plates than usual have been electrotyped for the Engineer Office of the Army and the Hydrographic Office of the Navy. Under an arrangement with these Offices, made by my predecessor, this work has been paid for at a fixed rate, and the Office has received from this source the sum of $1,991.42, which has been turned over by me to the Disbursing Office, and placed to the credit of our appropriation for electrotyping, &c. (See Sundry civil bill, 1884-'85; appropriation for Coast and Geodetic Survey Office expenses, paragraph 2.)

On the 2d of this month, I received the usual monthly statement of expenditures and available balances, and found that after allowing for all probable expenditure under this item, for the remainder of the year, there would still remain an available balance of nearly $3,000, enough to enable me to carry out certain much-needed improvements, which I had long contemplated, but had not means to undertake.

These were (1) an elevator to enable the bearers of our heavy copper plates to transport them readily between the printing office, near the basement of the building, and the engraving room in the upper story, and (2) a gas-engine of sufficient power to run the elevator, and also to supply power to the different work-shops—enabling more work to be done in all of them with less labor.

Having ascertained from the First Comptroller that the proposed expenditure was lawful, I proceeded, with your permission, to make the necessary contracts, and the work upon all of them is well in hand. When completed I feel sure that they will effect a great gain in both efficiency and comfort.

I have also fitted up a large room upon the lower floor of the Fire-proof building for a Library, which is now in a suitable place with plenty of light, and so near to the Archives that the keeper of the Archives can also act as Librarian.

The large space between the new Library and the Archives is to be fitted up with shelves for holding copper-plates. The rooms occupied by the old library are occupied for instruments, which are now near the instrument work-rooms, and easily accessible therefrom, while the room opposite, now filled with copper-plates, will be turned over to the Miscellaneous Division, which is in great need of more room for storage of heavy books that now overload the attic of the main building.

During the next six months I hope also to reorganize the Archives, and render the large and valuable mass of data collected there more accessible to all who have to consult our records.

The experience acquired in 1884 has enabled me to see opportunities for some retrenchment in the expenditures of the office, and last winter, with your consent, I reduced the estimates accordingly. The amount appropriated for office expenses during the fiscal year now beginning is $40,-800, while for the year ending to-day it has been $44,600, thus effecting a saving of $3,800. If other changes can be effected this sum may be still farther reduced in the next year.

The clerical duties of the office have been ably discharged by Dr. W. B. French, to whom I have been greatly indebted. He has taken entire charge of the accounts of the office, including the receipt and care for the funds received for sale of charts, amounting to $3,920.84, which amount has been turned into the Treasury.

Yours respectfully,

C. O. BOUTELLE,

*Assistant U. S. Coast and Geodetic Survey, in charge of Office.*

To the SUPERINTENDENT.

*REPORT OF THE COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR ENDING JUNE 30, 1885.*

COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE,
*July* 1, 1885.

DEAR SIR: In conformity with regulations, I herewith respectfully submit the usual annual report of work done by the several computers and others in this division of the office, for the fiscal year ending June 30, 1885.

The undersigned has continued in charge of the Computing Division, the personnel of which has with one exception remained as last year. The computing force sustained a serious loss by the resignation of Dr. J. G. Porter (now Director of the Cincinnati Observatory) soon after the beginning of the fiscal year. The place of this expert computer has not been filled. The Division was also deprived for nine months of the services of Mr. H. Farquhar, who was assigned to the party of Assistant C. S. Peirce.

This place was also left vacant during that time. The computing force being thus curtailed and having assigned to it the recomputation and adjustment to the Coast and Geodetic Survey triangulation of the Borden survey of Massachusetts, executed from 1832 to 1838, it became absolutely necessary to provide for some temporary assistance in order that the current work might be properly sustained. In consequence Mr. J. Nelson was assigned to the Computing Division from August 1, 1884, to September 20, 1884; Assistant O. H. Tittmann was assigned to it between September 16, 1884, and November 11; Assistant F. D. Granger reported for duty October 9, 1884, and was detached March 17, 1885; Mr. J. B. Boutelle reported for duty March 21, and continued to the close of the fiscal year; Mr. W. B. Fairfield reported for duty May 20, 1885, and left June 13, 1885; Mr. W. Auhagen was attached to the division during June, 1885. In consequence of the increased demand for professional information from field parties and for scientific and general information demanded in office correspondence, and in particular to satisfy calls from the United States Geological Survey, the services of Mr. E. A. Trescot as second clerk to the Division had to be retained throughout the year, and for nine days during June, 1885, Miss S. C. Ayres further assisted in copying records.

The Ooglaamie magnetic work, referred to in last year's report, was brought to a close soon after the beginning of the fiscal year, Sergeant (now Lieutenant) J. E. Maxfield being ordered on other duty July 12, 1884, and was seen through the press (forming 229 quarto pages) in May last. During this and the following month other heavy proof-reading (new edition of projection tables and new edition of table of factors for geodetic positions) was attended to. Special mention may be made of the following reports submitted by me:

On the results of the geodetic determination of the boundary lines of the District of Columbia; a discussion of the hypsometry of the Davidson quadrilaterals in central California; results of a new adjustment of all telegraphic longitudes, subject to geometrical conditions and determined by the Coast and Geodetic Survey; and an article entitled "The geodetic survey of the United States; its object and operations, considered from a theoretical and practical standpoint," with chart.

I have also completed a general collection of all magnetic dips and intensities determined in the United States from the earliest to the present time, arranged the material collected by States and Territories, and in each political division in the order of the latitudes of the stations and for each station, giving the separate results in chronological order. This work comprises nearly two thousand entries of dips and fifteen hundred entries of intensities. The discussion of the secular variation of the dip and of the horizontal and total intensities has been completed. I made also the usual annual determination of the magnetic elements at Washington on June 13 and 15, 1885.

The astronomical, geodetic, and magnetic records received at the office were examined for completeness of statements, and all data required in the office correspondence and referred to this division were promptly attended to.

A statement in detail of the work performed by each computer during the year is herewith appended.

Edward H. Courtenay attended to the preparation of geodetic data required by field parties to the geographical registers and the keeping of the duplicate records, completed the adjustment of the secondary triangulation of Massachusetts, had charge of the recomputation and adjustment to the triangulation of the Coast and Geodetic Survey of the Borden triangulation of Massachusetts during the years from 1832 to 1838, a work which he completed with the assistance of the extra computers temporarily assigned to the division. The triangulation of this State is thus made quite complete, and the results of the whole based on the best data, or made uniform with the standard data now in use. This recomputation was undertaken chiefly in aid of the Geological Survey and for the mapping of topography.

Myrick H. Doolittle completed the computation of tertiary geographical positions on Lake Champlain in 1870, '71, '72; computed the geodetic connection of the astronomical station Strasburg, Va.; computed secondary positions in Alabama and on the Florida Reef near Cape Florida; based the coast triangulation north of Point Conception, California (executed in 1867, '69, '74, '78, '79), on the results of the primary triangulation; determined the heights of the main triangulation points in the vicinity and north of Santa Barbara Channel 1873, '74, 75 (Tittmann), and 1882, '83, '84 (Lawson); prepared the manuscript for second edition of table of factors for computing geographical positions on the Clarke spheroid of 1866; compiled a part of the annual geodetic statistics of the Survey; computed some tertiary geographical positions in Georgia, Pennsylvania, and New Jersey; adjusted the heights of trigonometrical stations between Lake Champlain and Lake Ontario, 1874 to 1884; made miscellaneous geodetic revisions; assisted in proof-reading, and in part recomputed the new projection tables, and reduced magnetic observations at Philadelphia, 1884, at Providence and Newport, R. I., 1884, and at four stations in Florida, 1883 and 1884.

Jermain G. Porter computed the following telegraphic differences of longitude: Saint Louis, Mo., and London, Ky., Saint Louis and Guthrie, Ky., Saint Louis and Henderson, Ky., Saint Louis and Little Rock, Ark., Saint Louis and Springfield, Ill., Kansas City, Mo., and Indianapolis, Ind., all of 1882 and secondary stations; computed the telegraphic differences of longitude, Louisville, Ky., and Charleston, W. Va., Louisville and Chicago, Ill, Louisville and Lexington, Ky., and Louisville and Louisa, Ky., all of 1883. Resigned August 30, 1884.

Alexander S. Christie completed the computation of the azimuth at Pioche, Nev., 1883; furnished mean places of stars for field parties, revised the latitude computations of Charlottesville, Va., Keeney, W. Va., Kansas City, Mo., and Eureka, Nev.; computed time and azimuth, station Keeney, W. Va., 1880; computed the telegraphic differences of longitude, Louisville and Greensburg, Ky., and Louisville and Jellico, Tenn., Louisville and Richmond, Ky., Louisville and Logansport, Ind., all of 1883; computed the difference of longitude, Washington, D. C., and Covington, Va., 1884; recomputed the latitude of Madison, Wis.; computed the heights of the line of spirit levels between Hagerstown, Md., and Alexandria, Va., 1883-'84, aided in proof-reading of new edition of projection tables and completed the reduction of spirit levels in the District of Columbia, 1884.

Charles H. Kummell completed the computation of the triangulation of Hood's Canal, Washington Territory, 1881, and of 1882-'84; revised measures of horizontal angles, triangulation of Connecticut, 1883, and of stations Tepusquet, Lospe, and Saddle Peak, Cal.; computed a number of tertiary positions in Florida, Louisiana, Georgia, Kentucky, Tennessee, and Massachusetts (Cape Cod and Boston Harbor); assisted me in the solution of a number of normal equations relating to magnetic computations; computed the supplementary triangulation of Philadelphia by Assistants McCorkle and Sinclair and Sub-Assistant Van Orden, 1885, and verified abstracts of angles, survey of New York.

Henry Farquhar completed the computation for latitude of Pioche, Nev.; computed the latitude of Charlottesville, Va., and of Cincinnati, Ohio, and commenced the computation for latitude of Gratiot's Grove, Wis., and Sherrill's Mound, Iowa. Was detached from the Computing Division, September 27, 1884, and re-assigned June 23, 1885, when he took up the last-mentioned computations.

Alexander Ziwet computed the geographical positions fixing the boundary of the District of Columbia; computed the position of points of the main series of triangles of the Hudson River; computed positions, survey of Long Island Sound and of the survey along the boundaries of New York, Connecticut, and Massachusetts; prepared abstract of angles coast stations California, near

Piedras Blancas, 1883; assisted Mr. Courtenay in the adjustment of secondary points in Massachusetts of the Coast Survey and of the Borden survey, and in bringing up the latter and other results of tertiary triangulation to the modern standard data of the Coast and Geodetic Survey; he also adjusted a number of secondary positions in New Hampshire, made miscellaneous geodetic revisions, and assisted me in establishing and solving certain normal equations in connection with magnetic dips.

P. R. Stansbury discharged the clerical duties of the Computing Division, being principally engaged in keeping up to date the geographical registers, copying reports, and marking out descriptions of stations for the copyist.

E. A. Trescot was engaged as copyist; furnished descriptions of stations and sketches, and completed certain duplicates of records.

Temporary assistance was given by the following-named persons:

J. Nelson from August 1 to September 20, 1884, was engaged on position computations under direction of Mr. Courtenay.

Assistant O. H. Tittmann from September 16 to November 11, 1884, computed magnetic observations made at Philadelphia; assisted in the revision of angles and adjustment of the secondary triangulation of Massachusetts, connecting the Coast Survey triangulation with that of Borden, executed about half a century ago.

Assistant F. D. Granger from October 9, 1884, to March 18, 1885, was engaged in revising and adjusting the Borden angles at 109 stations in Massachusetts, and in revising angles of the Coast Survey measured in Massachusetts and New Hampshire in connection with the Borden work. He computed also a number of geographical positions.

J. B. Boutelle from March 21, 1885, to the close of the fiscal year, assisted in the computations connected with the supplementary triangulation of Massachusetts made by Assistant G. Bradford, 1884, and with the older one of Borden, computing improved geographical positions; assisted me in proof-reading of the paper containing full record and my discussion of the magnetic work done at Ooglaamie, Alaska, 1881–'82–'83 (station in charge of Lieutenant Ray, U. S. A.).

During June Mr. Boutelle had also temporary charge of the archives (a duty disconnected from the Computing Division).

W. B. Fairfield from May 20 to June 13, 1885, was engaged in miscellaneous computations of positions.

W. Auhagen during June, 1885, was engaged in the computation of geographical positions under the direction of Mr. Courtenay.

S. C. Ayres June 20 to 30, 1885, attended to miscellaneous copying.

I remain, sir, yours, respectfully,

CHARLES A. SCHOTT,
*Assistant in charge Computing Division.*

CHARLES O. BOUTELLE, Esq.,
*Assistant in charge Office and Topography.*

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*REPORT ON THE FIELD AND OFFICE WORK RELATING TO THE TIDES FOR THE YEAR ENDING JUNE* 30, 1885.

COAST AND GEODETIC SURVEY OFFICE,
*August* 28, 1885.

DEAR SIR: I respectfully submit this report on the work of the Tidal Division, of which I have been in charge during the year.

OBSERVATIONS.

Automatic tide-gauges, from which observations have been received or expected, have been used at the following stations:

Pulpit Harbor, North Haven, Me.; Providence, R. I.; New Haven Breakwater, Conn.; Governor's Island, N. Y.; Sandy Hook, N. J.; Fort Mifflin, near Philadelphia, Pa.; Charleston, S. C.;

Saucelito, Cal.; Saint Paul, Kadiak Island, Alaska; Fort Simpson, British Columbia; Honolulu, Sandwich Islands.

The gauges at Pulpit Harbor, Saucelito, and Saint Paul are kept running continually to obtain long unbroken series. The gauges near New Haven and at Governor's Island are run by hydrographic parties, and will be stopped during winter. The gauge at Sandy Hook does not work well in winter. It has not been doing good work for some months, and a better place should be found for it, where it can be run throughout the year.

Only a few observations have been received from Fort Mifflin, and those were not very good. A gauge should be used at Philadelphia by an experienced observer for at least a year, a good series there being much needed as a basis for predictions. Another automatic gauge will probably be established soon on the coast of Maine, in connection with the hydrographic work, the arrangements for which have been partly made. It has been found to add greatly to the value of hydrographic work to have it reduced by the aid of a good series of observations made with an automatic tide gauge, and where extensive surveys are in progress there should be at least one such gauge to serve as a basis for comparison with others.

The plan for obtaining a long series at Fernandina, or some place north of it on the Southern Coast, should be carried out, and the observations on the coasts of Louisiana and Texas, required for completing the tidal survey of the Gulf of Mexico, should be resumed and extended to a year at each place occupied. The range of the tides on these coasts is small, but their peculiar character gives them importance, as it is necessary to continue the observations day and night in order to get trustworthy data for reducing soundings, and this has not always been done.

In the following table I give a list of the stations at which automatic tide-gauges were in operation during the fiscal year, with names of observers and times of occupation of stations.

| Section. | Name of station. | Name of observer. | Kind of gauge. | Permanent or temporary. | Time of occupation. | | Total days. |
|---|---|---|---|---|---|---|---|
| | | | | | From— | To— | |
| I | Pulpit Harbor, Me | J. G. Spaulding | 2-roller | Permanent | April 27, 1884 | April 30, 1885 | 370 |
| I | Providence, R. I | S. M. Gray | do | Temporary | January 1, 1878 | December 31, 1880 | 960 |
| II | New Haven, Conn | L. B. Thompson | 3-roller | do | July 31, 1884 | June 1, 1885 | 173 |
| II | Sandy Hook, N. J | F. W. Shepheard | 2-roller | Permanent | July 1, 1884 | September 1, 1884 | 63 |
| | do | J. W. Corbett | do | do | March 31, 1885 | April 30, 1885 | 31 |
| II | Fort Mifflin, Pa | U. S. Engineers | 3-roller | Temporary | April 19, 1882 | October 22, 1883 | 176 |
| V | Charleston, S. C | do | 2-roller | do | January 1, 1885 | March 28, 1885 | 70 |
| X | Saucelito, Cal | E. Gray | 3-roller | Permanent | July 1, 1884 | May 31, 1885 | 336 |
| XII | Saint Paul, Alaska | William J. Fisher | do | do | December 1, 1883 | May 26, 1884 | 177 |
| | do | F. Sargent | do | do | May 27, 1884 | March 31, 1885 | 310 |

There are two 3-roller gauges and one 2-roller gauge in the Office, all ready for use.

The records received from the automatic gauges, and also those sent to the Office by the hydrographic parties, are inspected as soon as received; and reduced by the Tidal Division. Notices of them may be found in the accounts of work done in the different sections. The observations of the hydrographic parties are mostly made with staff or box gauges, and many of them only during daylight. This mode gives results of a fairly approximate nature for tidal phenomena on the Atlantic Coast, but on the coasts of the Pacific and Gulf of Mexico observations should be kept up both day and night, to obtain an accurate reduction for the soundings.

## OFFICE-WORK.

The observers at the permanent stations where automatic gauges are used have been taught to tabulate the high and low waters and hourly ordinates from the curves, before sending these to the Office, and to send first the tabulations, and afterward the curves. The loss by mails is thus made less serious, and the observers become more skillful and careful, while the amount of Office work is considerably reduced.

The observations obtained by the automatic gauges and by the hydrographic parties are reduced and discussed according to the most approved methods in the Tidal Division, and the results are used in the Chart tables, in the predictions, and for other purposes, and enable the Division to furnish a large amount of information about tides to Officers of the Survey, Civil and United States Engineers, and others, the demand for which is rapidly increasing.

"Tide Tables," containing the predictions for the Atlantic and Pacific Coasts of the United States for the year 1886, have been computed by the Tidal Division, and are being published, making the twentieth year of the series.

The predicting-machine invented by Professor Ferrel was more extensively used in this work than in predicting for 1885, and for some of the places improved constants were employed. Considerable labor was required in computing these constants, verifying them by trials, and in adapting these tables to the new mode of reckoning time.

The following computers have been employed in this Division in the course of the year: R. S. Avery, L. P. Shidy, M. Thomas, and C. B. Turnbull, in the Office; and J. G. Spaulding and L. J. Ferrel out of it.

Mr. Avery was in charge of the Division, and inspected all the tidal observations received, attended to the correspondence with observers and others relating to tides, planned and supervised the work on tides and tide-gauges, prepared the predictions for printing and read the proofs, and computed when not otherwise engaged.

Mr. Shidy tabulated and reduced many observations received from the automatic gauges and hydrographic parties, predicted for some places where the old methods had to be used, and with the predicting-machine for others; improved the tables for calculating components for the machine, computed and tested various components, and aided efficiently in much miscellaneous work. Miss Thomas worked on the simplest reductions and on the hourly ordinates for permanent stations, aiding sometimes on miscellaneous work and copying. Miss Turnbull has been employed in copying, tracing, and tabulating tides, and sometimes in aiding in easy reductions and miscellaneous work. Mr. Spaulding aided in computing components for use in making the predictions, in addition to his services as Tidal Observer at Pulpit Harbor.

Miss Ferrel worked on the discussion of observations by the Harmonic Analysis to find components to use in the predicting-machine, and for other purposes.

Respectfully submitted.

R. S. AVERY,
*In charge Tidal Division.*

Mr. B. A. COLONNA,
*Assistant in charge Coast and Geodetic Survey Office.*

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*REPORT OF THE DRAWING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR ENDING JUNE 30, 1885.*

COAST AND GEODETIC SURVEY OFFICE,
*Washington, June* 30, 1885.

DEAR SIR: In conformity with regulations I herewith submit the usual annual report of the work done by this division during the fiscal year ending June 30, 1885.

The following statement of work executed by the draughtsmen and the accompanying lists of charts and sketches, completed or in progress, together with the list of information (included in Appendix No. 3) furnished to meet special requests from official and non official sources, will serve to give an idea of the amount of work performed during the past year.

Besides the exhibit given in the above-mentioned statements, there have been constructed for field operations forty-four projections of various scales for topographical work, and fifty-five projections for hydrographic operations.

Diagrams in great numbers have been drawn for photolithographing to illustrate papers in the annual reports.

An average number of charts for quick publication by the photolithographic process were finished; a number of plane-table sheets were prepared and reproduced upon their original scales by the same process, and have given general satisfaction. The standard longitude has been marked upon the engraved plates as necessity demanded.

When not employed upon drawings of reduced scale for engraving upon copper, several of the draughtsmen were engaged in inking and lettering plane-table sheets for ultimate publication without material reduction in scale.

A synopsis of the work performed by each draughtsman during the fiscal year is given below.

Mr. A. Lindenkohl has drawn the additions to the annual progress sketches, reduced the topography and hydrography of a chart of Puget Sound from Admiralty Head to Seattle, scale 1–80000, and commenced the drawing of the upper part of the same from Seattle to Olympia; made additions to the series of Pacific Coast sailing-charts, scale 1–200000; compiled a new edition of the hydrography for Coast Chart No. 21, Sandy Hook to Barnegat Inlet, scale 1–80000; continued the topographical reduction of Coast Chart No. 2, Seal Island Light to Petit Manan Light, scale 1–80000, and the hydrography of Coast Chart No 14, Long Island Sound Eastern sheet, new edition, scale 1–80000, and has been engaged in keeping up to date the general charts of the Atlantic and Gulf Coasts, scale 1–400000, together with the sailing-charts, scale 1–1200000; he has also compiled for photolithographing, a large-scale chart of Newport Harbor and the entrance to Narragansett Bay, and partly reduced for engraving Charts Nos. 5 and 6 of the Columbia River, Oregon, from Kalama to Portland, scale 1–40000. He has also constructed projections for field parties, projections on copper, and made verifications and constructed numerous diagrams.

Mr. H. Lindenkohl has engraved upon stone the annual additions to a number of progress sketches, and drawn in a fine style for photolithographing, charts of New London Harbor and entrance to the Thames River; Thames River, New London to Norwich, scale 1–20000; Newport Harbor and entrance to Narragansett Bay, scale 1–20000; reduced topography and hydrography for general charts of the coast No. I, Quoddy Head to Cape Cod; No. VI, Cape Hatteras to Cape Romain; No. XI, Key West to Tampa Bay; No. XII, Tampa Bay to Cape San Blas, scales 1–400000; made additions to a chart of New York Harbor for the Pilot Commissioners; drawn for photolithographing several charts of harbors and sounds in Alaska; continued the hydrographic and topographical reductions for Pacific Coast Chart No. 3, Point Concepcion to San Louis Obispo, Cal., scale 1–200000; engraved diagrams on stone illustrating papers in the annual report; and constructed field projections and projections upon copper. He has also completed the reduction of topography, scale 1–40000, of the Columbia River, Sheets Nos. 5 and 6, Kalama to Portland, and has been employed upon various kinds of miscellaneous work.

Mr. C. Junken has been generally engaged upon hydrographic reductions of various scales, as follows: Coast Chart No. 50, Cape Fear River and approaches, scale 1–80000; Coast Chart No. 2, Seal Island Light to Petit Manan Light, scale 1–80000; Coast Chart No. 77, Tampa Bay, Florida, scale 1–80000; entrance to Cape Fear River, North Carolina, scale 1–30000; Coast Chart No. 76, Charlotte Harbor to Tampa Bay, Florida, scale 1–80000; Coast Chart No. 75, Charlotte Harbor and San Carlos Bay, Florida, scale 1–80000; topography and hydrography of Coast Chart No. 47, Cape Lookout and vicinity; hydrography of Port Gamble and vicinity, Washington Territory, scale 1–20000; hydrography for a new edition of Savannah River, Georgia, scale 1–40000; additional hydrography for Pacific Coast Chart No. 6, San Francisco to Point Arena, California, scale 1–200000; has compiled for photolithographing charts of Fisher's Island Sound, scale 1–40000, and Gray's Harbor, Washington Territory, scale 1–40000. He was also employed in constructing field projections and copper-plate projections. From the 15th of November to the 3d of January, Mr. Junken was engaged on the special duty of determining and marking points on the boundary line between Maryland and Virginia, in the vicinity of Pocomoke Sound.

Mr. E. J. Sommer has reduced to the publication scale the hydrography of New London Harbor, scale 1–20000; topography and hydrography of coast chart No. 62, Cape Canaveral southward, scale 1–80000; coast chart No. 63, Indian River Shoals to Jupiter Inlet Light, scale 1–80000; made smooth drawings for photolithographing of several harbors in Alaska; also prepared for the same process the original hydrographic and topographical sheets, coast of California, south of Point Pinos, including Carmel Bay, to be upon the scale of 1–12000. He has made field projections, copper-plate projections, and done other miscellaneous work.

Mr. T. J. O'Sullivan has made finished drawings for photolithographing, sketches of the transcontinental triangulation from San Francisco eastward, scale 1-2000000; harbors in Alaska; inked and lettered plane-table sheets south side Long Island; Hood's Canal and Puget Sound; reduced additional topography for harbor chart coast of Maine, No. 11, Cape Split to Schoodic Island, scale 1-40000; made verifications, finished sketches and diagrams for annual report; made tracings and done general lettering.

Mr. P. Erichsen, in addition to calculating the areas of engraved topography for use in the Engraving Division, was engaged in inking plane-table sheets of Hood's Canal, Washington Territory; coast of California; Chandler's River Bay, Maine; shores of the Delaware Bay, and Indian River, Florida. He also made tracings and mechanical drawings, and did verification.

Mr. L. Karcher rejoined the office in July, and has principally been engaged in constructing numerous field projections, making projects and tracings, and has been engaged in other miscellaneous duties.

Mr. E. H. Fowler has inked and lettered plane-table sheets coast of New Jersey; Columbia River, Oregon; coast of California, and south side Long Island; reduced topography for coast chart No. 37, scale 1-80000, Norfolk and vicinity; additional topography for chart of Savannah River, Georgia, scale 1-40000, and been engaged on small diagrams and tracings. He has made the finished drawing for a new edition of the chart of Gray's Harbor, Washington Territory, scale 1-40000.

Mr. E. Molkow has inked and lettered plane-table sheets of New London and vicinity, Conn.; coast of California; coast north of Cape Henlopen; south side of Long Island; Chandler's River Bay, Maine; Machiasport and vicinity, Maine; made projects and diagrams, and attended to the measurements of the topographical sheets for the annual table of statistics.

Mr. A. B. Graham continued the construction of hydrographic projections, projects, photolithographic drawings, and miscellaneous tracings. Mr. Graham resigned in April.

Mr. J. C. Barr was occupied as clerk to the division during part of the year; afterwards his time was given to the coloring of lights and buoys on charts.

Mr. J. H. Barker has been employed in coloring buoys and light-houses on charts and in making additions and corrections to the newly printed charts.

Yours respectfully,

W. T. BRIGHT.

Mr. C. O. BOUTELLE,
*Assistant in Charge of Office.*

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## DRAWING DIVISION.

*Charts completed or in progress during the year ending June 30, 1885.*

1. Topography. 2. Hydrography.

| Number of charts. Series. | Catalogue. | Title of charts. | Scale. | Draughtsmen. | Remarks. |
|---|---|---|---|---|---|
| | | ATLANTIC COAST. | | | |
| | | GENERAL COAST CHARTS. | | | |
| I | 6 | Quoddy Head to Cape Cod | 1-400, 000 | 1. H. Lindenkohl | Additions. |
| VI | 11 | Cape Hatteras to Cape Romain | 1-400, 000 | 1. H. Lindenkohl | Do. |
| XI | 16 | Key West to Tampa Bay | 1-400, 000 | 1, 2. A. Lindenkohl. 1. H. Lindenkohl. | Do. |
| XII | 17 | Tampa Bay to Cape San Blas | 1-400, 000 | 1. H. Lindenkohl. 2. A. Lindenkohl. | Do. |
| XIV | 19 | Mobile Bay to Atchafalaya Bay | 1-400, 000 | 1, 2. A. Lindenkohl | Do. |

*Charts completed or in progress during the year ending June 30, 1885*—Continued.

1. Topography. 2. Hydrography.

| Number of charts. Series. | Number of charts. Catalogue. | Title of charts. | Scale. | Draughtsmen. | Remarks. |
|---|---|---|---|---|---|
| | | ATLANTIC COAST—Continued. | | | |
| | | COAST CHARTS. | | | |
| 2 | 102 | Seal Island Light to Petit Manan Light | 1-80,000 | 2. C. Junken. 1. A. Lindenkohl. 2. L. Karcher. 2. H. Lindenkohl. | In progress. |
| 3 | 103 | Frenchman's and Blue Hill Bays | 1-80,000 | 1. A. Lindenkohl. 1. H. Lindenkohl. | Additions. |
| 14 | 114 | Newport to Plum Island Light | 1-80,000 | 1, 2. A. Lindenkohl. 1, 2. H. Lindenkohl. | In progress. |
| 31 | 131 | Entrance to Chesapeake Bay, Hampton Roads, &c | 1-80,000 | 1, 2. A. Lindenkohl | Additions. |
| 21 | 121 | New York Bay and Harbor | 1-80,000 | 2. A. Lindenkohl | Do. |
| 37 | 137 | Cape Henry to Currituck Beach | 1-80,000 | 1, 2. E. J. Sommer. 1. E. H. Fowler. | Do. |
| 47 | 147 | Cape Lookout and vicinity | 1-80,000 | 1, 2. C. Junken | Completed. |
| 50 | 150 | Cape Fear River and approaches | 1-80,000 | 1, 2. C. Junken | Do. |
| 53 | 153 | Winyah Bay to Long Island, S. E | 1-80,000 | 2. A. Lindenkohl | Additions. |
| 62 | 162 | Cape Canaveral to Indian River Light | 1-80,000 | 1, 2. E. J. Sommer | Completed. |
| 63 | 163 | Indian River Light to Jupiter Inlet Light | 1, 80,000 | 1. E. J. Sommer | In progress. |
| 75 | 175 | Charlotte Harbor and San Carlos Bay | 1-80,000 | 2. C. Junken | Additions. |
| 76 | 176 | Charlotte Harbor to Tampa Bay | 1-80,000 | 2. C. Junken | Completed. |
| 77 | 177 | Tampa Bay and approaches | 1-80,000 | 2. C. Junken | Additions. |
| 94 | 194 | Mississippi River, from the Passes to Grand Prairie | 1-80,000 | 1. H. Lindenkohl | Do. |
| 105 | 205 | Galveston Bay to Oyster Bay | 1-80,000 | 1. A. Lindenkohl | Do. |
| | | HARBOR CHARTS. | | | |
| 11 | 305 | Cape Split to Schoodic Island, Me | 1-40,000 | 1, 2. T. J. O'Sullivan | Additions. |
| | 318 | Bar Harbor, Me | 1-10,000 | 1. H. Lindenkohl | Do. |
| | 306 | Frenchman's Bay and Somes' Sound | 1-40,000 | 1. E. Molkow | Do. |
| | $353^2$ | Newport Harbor and Entrances to Narragansett Bay | 1-20,000 | 1, 2. A. Lindenkohl. 1, 2. H. Lindenkohl. | Photo-lith.; completed. |
| | 356 | Fisher's Island Sound | 1-40,000 | 1, 3. C. Junken. 1, 2. H. Lindenkohl. | Do. |
| | 359 | New London Harbor and Entrance to Thames River | 1-20,000 | 1, 2. A. Lindenkohl. 1, 2. H. Lindenkohl. | Do. |
| | 359*a* | Thames River, New London to Norwich | 1-20,000 | 1, 2. H. Lindenkohl. 1. T. J. O'Sullivan. | Do. |
| | $369^2$ | New York Entrance | 1-40,000 | 1. A. Lindenkohl | Additions. |
| | $369^3$ | New York Harbor and parts of Hudson and East Rivers. | 1-10,000 | 2. A. Lindenkohl. 2. H. Lindenkohl (for Board of Pilot Commissioners). | Completed. |
| | 424 | Cape Fear River Entrance | 1-30,000 | 2. C. Junken | Additions. |
| | 440 | Savannah River and Wassaw Sound | 1-40,000 | 1. E. H. Fowler. 2. C. Junken | Do. |
| | | PACIFIC COAST. | | | |
| | | HARBOR CHARTS. | | | |
| | 621*a* | San Francisco Entrance (new edition) | 1-40,000 | 2. L. Karcher | Do. |
| | 641*c* | Columbia River, Kalama to Willow Bar | 1-40,000 | 1, 2. A. Lindenkohl. 1, 2. H. Lindenkohl. | In progress. |
| | 641*d* | Columbia River, Willow Bar to Portland | 1-40,000 | 1. H. Lindenkohl | Do. |
| | 643 | Gray's Harbor, W. T. (new edition) | 1-40,000 | 2. C. Junken. 1, 2. E. H. Fowler. | Photo-lith.; completed |
| | 650 | Port Gamble, W. T. (new edition) | 1-20,000 | 1, 2. C. Junken | Completed. |
| | | SAILING CHARTS. | | | |
| | 673 | Point Concepcion to San Luis Obispo | 1-200,000 | 2. H. Lindenkohl | Additions. |
| | 676 | San Francisco to Point Arena | 1-200,000 | 1, 2. C. Junken | Do. |
| | 662*a* | Puget Sound, Admiralty Head to Olympia | 1-80,000 | 1, 2. A. Lindenkohl. 1. H. Lindenkohl. | Completed. |
| | 662*b* | Puget Sound, Seattle to Olympia | 1-80,000 | 1, 2. A. Lindenkohl | In progress. |

*REPORT OF THE ENGRAVING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR ENDING JUNE 30, 1885.*

U. S. COAST AND GEODETIC SURVEY OFFICE,
*Washington, July 1, 1885.*

SIR: I respectfully submit the following report of work executed in the Engraving Division during the year ending June 30, 1885.

The corrections to the plates, required before printing for issue, have continued to increase in number and from the numerous additions from resurveys have required more labor than in former years.

Four hundred and twenty-one chart plates and fourteen sketches were corrected, in addition to extensive alterations in new printing plates electrotyped from the standard altos. We have also had the usual amount of cleaning electrotypes, erasures from altos, arranging and drawing titles, general lettering and notes, marking instruments, &c.

Several important charts have been well advanced in addition to those completed, but the time required in correcting the printing plates and bringing up new electrotype copies, seriously interferes with the production of new charts.

This work is necessarily of the first importance, as the published charts must be kept up to date so far as as information received will permit; the time required for it is on the increase, and I cannot urge upon you too strongly the consideration of suitable methods to bring the surveys before the public in preliminary form, and thus give more time for the completion of the finished charts without delaying the publication of important new surveys.

The engravers have been employed as follows: Messrs. Joseph Enthoffer, W. A. Thompson, H. C. Evans, R. F. Bartle, and E. J. Enthoffer, on Topography and Sand. Messrs. E. A. Maedel, A. Petersen, J. G. Thompson, and F. Courtenay, on Lettering. Messrs. E. H. Sipe, W. H. Davis, and A. C. Ruebsam, on Lettering and Miscellaneous Corrections; and Messrs. H. M. Knight and T. Wasserbach, on Lettering, Sand, and Miscellaneous Corrections.

The electrotyping of the copper plates has continued under my direction with the immediate supervision of Dr. A. Zumbrock, assisted by Frank Over.

The improvements made in the batteries have resulted in more regular work. The batteries do not break down and are more readily cared for, requiring much less labor. Observations are now being made to determine the relative values of the carbon and our old silver plates.

The printing for the chart room during the year has fallen off about 14 per cent. of the preceding year's work, or over 4,500 impressions. This is largely due to the interruption caused by building the addition to the printing room, and the failure of the contractors to keep up the supply of chart paper. For about two months it was impossible to fill the requisitions from the chart room with the usual promptness, which has doubtless resulted in a diminished issue to the sale agents.

The new press room affords much better light and facilities for work, and being on a level with the street, instead of below it, will doubtless prove more healthful to the workmen. It is sufficiently large to accommodate the new 38-inch copper-plate press, in addition to the two old presses, and will permit the requisite increase of force when the demand for charts shall make an increase necessary.

The force of printers has remained the same; the presses have been in charge of Mr. F. Moore, foreman, and Messrs. D. N. Hoover and James L. Smith.

Mr. John H. Smoot has continued as clerk to the division, and I take pleasure in commending his strict attention to his duties, and the very satisfactory chart proof-reading he now furnishes.

*Statistics of work.*

ENGRAVING.

| | |
|---|---|
| Number of plates completed: | |
| Charts | 11 |
| New editions | 9 |
| Sketches and illustrations | 5 |
| | 25 |

| | |
|---|---|
| Number of plates continued: | |
| Charts | 15 |
| New editions | 1 |
| Sketches and illustrations | 4 |
| | 20 |
| Number of plates commenced: | |
| Charts | 8 |
| New editions | 12 |
| Sketches and illustrations | 5 |
| | 25 |
| Number of plates corrected for printing: | |
| Charts | 421 |
| Sketches | 14 |
| | 435 |
| Number of unfinished plates on hand at the close of the year: | |
| Charts | 41 |
| Sketches and illustrations | 28 |
| | 69 |

ELECTROTYPING.

| | |
|---|---|
| Number of pounds of copper deposited | 2, 534 |
| Number of square inches on which deposit was made | 124, 937 |
| Number of copper plates made: | |
| Bassos | 46 |
| Altos | 61 |
| | 107 |

Of which number 13 basso and 14 alto plates were for the Engineer Corps, U. S. A. (Lake Survey), and 7 basso and 7 alto plates for the Hydrographic Office, Navy Department. In photographing, 44 negatives were made and 127 prints.

PRINTING.

| | |
|---|---|
| Number of impressions for Chart Room | 26, 488 |
| Number of impressions for Assistant in charge of Office | 1, 221 |
| Number of impressions for Engraving Division | 1, 652 |
| Number of impressions for Hydrographic Inspector | 1, 032 |
| Number of impressions for Lithographer (transfer proofs) | 224 |
| Number of impressions for Atlantic Coast Pilot, vol. 4 Charts and Views | 5, 436 |
| Total | 36, 053 |

I append hereto a list of the copper plates that were completed, continued, or commenced during the year.

I am, sir, yours, very respectfully,

HERBERT G. OGDEN,
*Assistant Coast and Geodetic Survey,*
*In charge of Engraving Division.*

C. O. BOUTELLE, Esq.,
*Assistant in charge Office and Topography.*

*Plates completed, continued, or commenced during the fiscal year ending June 30, 1885.*

1. Outlines. 2. Topography. 3. Sanding. 4. Lettering.

| Catalogue No. | Plate No. | Title. | Scale. | Engravers and work. |
|---|---|---|---|---|
| | | COMPLETED. | | |
| 14 | 1843 | Cape Canaveral to Fowey Rocks | 1-400, 000 | 1, 2. R. F. Bartle and W. A. Thompson. 4. E. A. Maedel and J. G. Thompson. |
| 145 | 1725 | Cape Hatteras to Ocracoke Inlet | 1-80, 000 | 4. T. Wasserbach and E. A. Ruebsam. |
| 181 | 1450 | Apalachee Bay | 1-80, 000 | 3. F. Courtenay and E. A. Ruebsam. 4. T. Wasserbach and A. C. Ruebsam. |
| 208 | 1247 | Pass Cavallo, Lavaca and San Antonio Bays | 1-80, 000 | 1, 2. W. A. Thompson. 4. A. C. Ruebsam. |
| 209 | 1248 | Aransas Pass, Aransas and Copano Bays | 1-80, 000 | 2, 3. W. A. Thompson and J. G. Thompson. 4. A. C. Ruebsam. |
| 306 | 1186 | Frenchman's Bay and Eastern Part of Mount Desert Island. | 1-40, 000 | 4. E. A. Maedel, J. G. Thompson, and A. C. Ruebsam. |
| 307 | 1265 | Blue Hill Bay and Western Part of Mount Desert Island. | 1-40, 000 | 1, 2, 3. W. A. Thompson. 4. E. A. Maedel, J. G. Thompson, W. H. Davis, and A. C. Ruebsam. |
| 308 | 1376 | Approaches to Blue Hill Bay and Eggemoggin Reach | 1-40, 000 | 2, 3. W. A. Thompson. 3. H. M. Knight and H. C. Evans. 4. J. G. Thompson and A. C. Ruebsam. |
| 676 | 1741 | San Francisco to Point Arena | 1-200, 000 | 1, 2, 3. W. A. Thompson. 4. E. A. Maedel, J. G. Thompson, and A. C. Ruebsam. |
| 681*a* | 1799 | Approaches to the Columbia River | 1-200, 000 | 4. J. G. Thompson. |
| 621*a* | 1829 | San Francisco Entrance | 1-40, 000 | 1, 2, 3. W. A. Thompson. 3. T. Wasserbach. 4. A. Petersen, J. G. Thompson, and W. H. Davis. |
| 205 | 1216 | Galveston Bay to Oyster Bay, edition 1884 | 1-80, 000 | 3. W. A. Thompson and T. Wasserbach. 4. A. Petersen, T. Wasserbach, and W. H. Davis. |
| 424 | 1161 | Cape Fear River Entrance, edition 1884 | 1-30, 000 | 1, 2, 3. H. M. Knight. 3, 4. T. Wasserbach. 4. A. C. Ruebsam. |
| 520 | 1830 | Galveston Entrance, edition 1884 | 1-40, 000 | 3. T. Wasserbach. 4. A. Petersen, W. H. Davis, and A. C. Ruebsam. |
| 30 | 97 | Galveston Bay, edition 1884 | 1-200, 000 | 3, 4. W. H. Davis. |
| 111 | 1809 | Monomoy and Nantucket Shoals to Muskeget Channel, edition 1885. | 1-80, 000 | 3. H. M. Knight. 4. H. M. Knight, E. H. Sipe, and A. C. Ruebsam. |
| 194 | 1845 | Mississippi River from the Passes to Grand Prairie, edition 1885. | 1-80, 000 | 1, 2, 3. W. A. Thompson. 4. A. C. Ruebsam. |
| 318 | 1857 | Bar Harbor, Mount Desert Island, edition 1885 | 1-10, 000 | 1, 2. E. J. Enthoffer. 3. W. A. Thompson. 4. W. H. Davis. |
| 344 | 1836 | Monomoy Passage, edition 1885 | 1-40, 000 | 3, 4. H. M. Knight. 4. F. Courtenay and A. C. Ruebsam. |
| 650 | 1851 | Port Gamble, edition 1885 | 1-20, 000 | 1, 2, 3. R. F. Bartle. 4. F. Courtenay and W. H. Davis |
| | 1859 | Progress Sketch No. 6, West Coast of Florida, Cape Sable to Charlotte Harbor. | 1-200, 000 | 1, 4. A. C. Ruebsam. |
| | 1839 | Atlantic Coast Pilot Chart, Cape Henry to Cape Lookout. | 1-400, 000 | 4. A. C. Ruebsam. |
| | 1840 | Atlantic Coast Pilot Chart, Cape Lookout to Cape Romain. | 1-400, 000 | 4. A. C. Ruebsam. |
| | 1864 | Atlantic Coast Pilot Chart, Frying Pan Shoals to Wassaw Sound. | 1-400, 000 | 4. A. C. Ruebsam. |
| | 1726 | Atlantic Coast Pilot View, Tybee Entrance, Tybee Roads, &c. | ............ | 4. W. H. Davis. |
| | | CONTINUED. | | |
| D | 1653 | Gulf of Mexico | 1-2, 100, 000 | 3. W. A. Thompson. 4. E. A. Maedel and J. G. Thompson. |
| 102 | 1742 | Seal Island to Petit Manan | 1-80, 000 | 1, 2. Joseph Enthoffer. 3. H. M. Knight. 4. J. G. Thompson and A. C. Ruebsam. |
| 150 | 1841 | Cape Fear and Approaches | 1-80, 000 | 1, 2. H. C. Evans. 4. A. Petersen. |
| 153 | 1503 | Winyah Bay to Long Island | 1-80, 000 | 4. H. M. Knight. |
| 180 | 1746 | Cedar Keys to Deadman's Bay | 1-80, 000 | 3. E. A. Ruebsam. 4. F. Courtenay and A. C. Ruebsam. |
| 184 | 1601 | Saint Joseph's Bay to Saint Andrew's Bay | 1-80, 000 | 3, 4. H. M. Knight. 4. A. C. Ruebsam. |
| 185 | 1498 | Saint Andrew's Bay to Choctawhatchee Inlet | 1-80, 000 | 4. A. C. Ruebsam. |
| 192 | 1537 | Chandeleur and Breton Island Sounds | 1-80, 000 | 3. F. Courtenay and E. A. Ruebsam. |
| 204 | 1316 | Galveston Bay | 1-80, 000 | 3, 4. T. Wasserbach. 4. A. Petersen and W. H. Davis. |
| 210 | 1778 | Corpus Christi Bay and Pass | 1-80, 000 | 3. E. A. Ruebsam. 4. A. Petersen and A. C. Ruebsam. |
| 305 | 1821 | Pleasant Bay to Prospect Harbor | 1-40, 000 | 1, 2. R. F. Bartle. 4. A. Petersen and E. A. Ruebsam. |
| 359*a* | 1798 | Thames River and New London Harbor | 1-40, 000 | 1, 2, 3. H. M. Knight. 4. A. Petersen. |

*Plates completed, continued or commenced during the fiscal year ending June 30, 1885.*

1. Outlines. 2. Topography. 3. Sanding. 4. Lettering.

| Catalogue No. | Plate No. | Title. | Scale. | Engravers and work. |
|---|---|---|---|---|
| | | CONTINUED. | | |
| 401e | 1679 | James River No. 5, Kingsland Creek to Richmond | 1-20,000 | 3, 4. H. M. Knight. |
| 673 | 1800 | Point Conception to San Luis Obispo | 1-200,000 | 4. A. Petersen. |
| 669 | 1828 | San Luis Obispo Bay | 1-20,000 | 1, 2. E. J. Enthoffer. 3. T. Wasserbach. |
| | 1789 | Trinidad Harbor, California | 1-40,000 | 4. A. C. Ruebsam. |
| | 1793 | Saint George's Reef, Crescent City, and Cape Orford | 1-80,000 | 4. A. C. Ruebsam. |
| | 1805 | San Francisco Entrance | 1-80,000 | 4. A. C. Ruebsam. |
| | 1820 | San Diego Bay, California | 1-100,000 | 1, 2. E. J. Enthoffer. 4. F. Courtenay. |
| 120 | 1785 | New York Bay and Harbor, new edition | 1-80,000 | 1, 2. W. A. Thompson. 3. H. M. Knight. 4. A. Petersen and F. Courtenay. |
| | | COMMENCED. | | |
| 16 | 1855 | General Coast Chart No. 11, Key West to Tampa Bay | 1-400,000 | 1, 2. R. F. Bartle. 4. A. Petersen. |
| 147 | 1861 | Cape Lookout | 1-80,000 | 1, 2. Joseph Enthoffer. |
| 148 | 1862 | Bogue Inlet to New Topsail Inlet | 1-80,000 | 1, 2. R. F. Bartle. |
| 162 | 1844 | Cape Canaveral southward to latitude 27° 41′ | 1-80,000 | 1, 2. H. C. Evans. 4. E. H. Sipe. |
| 176 | 1848 | Lemon Bay to Tampa Bay | 1-80,000 | 1, 2. R. F. Bartle. 4. A. Petersen and E. A. Ruebsam. |
| 379 | 1847 | Delaware Breakwater | 1-20,000 | 1, 2. E. J. Enthoffer. 3. E. A. Ruebsam. 4. A. Petersen and F. Courtenay. |
| 685 | 1834 | Admiralty Inlet | 1-80,000 | 1, 2. Joseph Enthoffer. 4. A. Petersen. |
| 690 | 1865 | Commencement Bay | 1-20,000 | 1, 2. E. J. Enthoffer. |
| 30 | 97 | Galveston Bay, new edition | 1-200,000 | 3, 4. W. H. Davis. |
| 111 | 1809 | Monomoy and Nantucket Shoals to Muskeget Channel, new edition. | 1-80,000 | 3, 4. H. M. Knight. 4. E. H. Sipe and A. C. Ruebsam. |
| 121 | 1856 | Sandy Hook to Barnegat Inlet, new edition | 1-80,000 | 4. F. Courtenay. |
| 177 | 1852 | Tampa Bay, new edition | 1-80,000 | 3. E. A. Ruebsam. 4. F. Courtenay. |
| 194 | 1845 | Mississippi River, from the Passes to Grand Prairie, new edition. | 1-80,000 | 1, 2, 3. W. A. Thompson. 4. A. C. Ruebsam. |
| 205 | 1216 | Galveston Bay to Oyster Bay, new edition | 1-80,000 | 3. W. A. Thompson and T. Wasserbach. 4. A. Petersen, T. Wasserbach, and W. H. Davis. |
| 318 | 1857 | Bar Harbor, Mount Desert Island, new edition | 1-10,000 | 1, 2. E. J. Enthoffer. 3. W. A. Thompson. 4. W. H. Davis. |
| 344 | 1836 | Monomoy Passage, new edition | 1-40,000 | 3, 4. H. M. Knight. 4. F. Courtenay and A. C. Ruebsam. |
| 424 | 1161 | Cape Fear River Entrance, new edition | 1-30,000 | 2, 3. H. M. Knight. 4. A. C. Reubsam. |
| 520 | 1836 | Galveston Entrance, new edition | 1-40,000 | 3. W. A. Thompson. 4. A. Petersen, W. H. Davis, and A. C. Ruebsam. |
| 650 | 1851 | Port Gamble, new edition | 1-20,000 | 1, 2, 3. R. F. Bartle. 4. F. Courtenay and W. H. Davis. |
| 440 | 1831 | Savannah River and Wassaw Sound, new edition | 1-40,000 | 1, 2. W. A. Thompson. 4. A. Petersen. |
| | 1859 | Progress Sketch section 6 West Coast of Florida, Cape Sable to Charlotte Harbor. | 1-200,000 | 1, 4. A. C. Ruebsam. |
| | 1839 | Atlantic Coast Pilot Chart, Cape Henry to Cape Lookout. | 1-400,000 | 4. A. C. Ruebsam. |
| | 1840 | Atlantic Coast Pilot Chart, Cape Lookout to Cape Romain. | 1-400,000 | 4. A. C. Ruebsam. |
| | 1864 | Atlantic Coast Pilot, Chart Frying Pan Shoals to Wassaw Sound. | 1-400,000 | 4. A. C. Ruebsam. |
| | 1858 | Atlantic Coast Pilot Chart Coast, and Inland Passage from Charleston to Fernandina. | 1-400,000 | 4. A. C. Ruebsam. |

## *REPORT OF THE MISCELLANEOUS DIVISION FOR THE YEAR ENDING JUNE 30, 1885.*

U. S. COAST AND GEODETIC SURVEY OFFICE,
*Washington, August 25, 1885.*

SIR: I have the honor to submit herewith the report of this Division for the year ending June 30, 1885.

The work of the Division was of the same general character as in former years. The Annual

Report of the Superintendent for the year ending June 30, 1883, which had been sent to press in the preceding fiscal year, was published, and the usual distribution of the volume was made.

First editions of the Pacific Coast Pilot, Alaska, Part 1 (Dixon Entrance to Yakutat Bay, with the Inland Passages), and of Subdivision 19, Atlantic Coast Pilot (Cape Henry to Winyah Bay, and Inside Passages), were published. Subdivision 20, Atlantic Coast Pilot (Winyah Bay to Savannah, with the Inside Passage to Fernandina) was sent to press. A revised edition of Appendix 22, Report for 1882 (Report of a conference on gravity determinations), and the "Summary Report of the Progress of the United States Coast and Geodetic Survey for the fiscal year ending with June, 1884," were also printed. The Annual Report of the Superintendent for the fiscal year ending June 30, 1884, was sent to press, and satisfactory progress made towards its publication. It is expected that this volume will be ready for distribution before the Report for 1885 is submitted to Congress. The Tide Tables for the Pacific Coast for the year 1886 were also sent to press.

The following aggregates of publications of the Survey were received from the Public Printer during the year:

| | Copies. |
|---|---|
| Annual Report for 1883 | 3,019 |
| Appendices to Annual Reports (extra copies) | 4,600 |
| Notices to Mariners, Nos. 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62 | 6,800 |
| Atlantic Local Coast Pilot, Subdivision 19 | 522 |
| Pacific Coast Pilot, Alaska, Part 1 | 499 |
| Summary of Report of Superintendent for 1884 | 300 |
| Description of Coast and Geodetic Survey Exhibit at the Cotton Centennial Exposition at New Orleans | 1,000 |

A detailed list of the above-mentioned publications is appended hereto.

The usual distribution of the publications of the Survey to Institutions, individuals, and the Departments was made, and the Notices to Mariners and Appendices to Annual Reports, in pamphlet form, were distributed gratuitously, as heretofore.

Two thousand four hundred and eighty-eight copies of the Annual Reports were distributed during the year; also, six hundred and eighty-six copies of the Atlantic Coast Pilot, including Subdivisions, and one hundred and ninety-two copies of the Pacific Coast Pilot.

There were received in the Chart-room during the year 29,525 sheets of charts, of which 23,760 were copper-plate impressions, and 5,765 were printed from stone. Twelve thousand one hundred and sixty-three copies were furnished to the several Executive Departments and to Senators and Representatives, and 14,035 sheets were deposited with Sale Agents. The total issue of charts during the year was 28,905 copies, being 4,733 copies less than the total issue of the preceding year. (See statement appended hereto.)

Mr. Hugo G. Eichholtz has continued in charge of the Chart-room, and the issue of charts has been made under his immediate supervision.

Mr. H. O. French has been in charge of the Carpenter shop as Chief Carpenter. The carpenter work of the office, including the wood-work of instruments, making packing-cases and patterns, packing instruments for transportation, the construction of frames, vats, &c., for electrotyping, press-boards, &c., for the plate-printing room, repairs of furniture, &c., has been done by Mr. French, assisted by Messrs. G. F. Cox and G. W. Clarvoe.

Mr. R. T. Bassett has been in charge of the map-mounting room, as heretofore. Mr. N. Y. Cavitt performed the duties of janitor until the 1st of May, 1885, when he was succeeded by Mr. W. M. Long, who has since acted in that capacity. Upon the promotion of Mr. Long from watchman to janitor Mr. Charles O. Rockwell was appointed watchman by the Superintendent. Charles E. Brown was employed as night fireman from November 26, 1884, to May 31, 1885. With these two exceptions, there have been no changes in the force of watchmen, messengers, and laborers.

Yours, respectfully,

M. W. WINES,
*Chief of Miscellaneous Division.*

B. A. COLONNA, Esq.,
*Assistant in charge of Office and Topography.*

*List of Publications of the Coast and Geodetic Survey received from the Public Printer during the fiscal year ending June 30, 1885.*

| Name of publication. | Number of copies. |
| --- | --- |
| Annual Report for 1883 | 3,019 |
| Atlantic Coast Pilot, Subdivision 19—Cape Henry to Winyah Bay, and Inside Passages | 522 |
| Pacific Coast Pilot, Alaska, Part 1—Dixon Entrance to Yakutat Bay, with the Inland Passages | 499 |
| Summary of Report of Superintendent for 1884 | 300 |
| Report of a conference on Gravity Determinations. (Revised edition of Appendix 22, Report for 1882) | 200 |
| Short descriptions of Articles forming the Coast and Geodetic Survey Exhibit at the Cotton Centennial Exposition, New Orleans, La., 1884-'85 | 1,000 |
| NOTICES TO MARINERS. | |
| No. 52.—Dangerous Rock in East River, New York | 500 |
| No. 53.—Changes in the Pilotage Laws of the Port of New York | 1,000 |
| No. 54.—Rocks recently reported on the Coast of New England | 500 |
| No. 55.—Dangerous ledges developed in the resurvey of Long Island Sound | 500 |
| No. 56.—Shoal developed in Vineyard Sound | 500 |
| No. 57.—Discovery of a rock in Security Bay, Chatham Strait, Alaska | 500 |
| No. 58.—Development of shoals in Narragansett Bay, R. I., and Block Island Sound | 500 |
| No. 59.—Changes in main ship-channel, Vineyard Sound | 500 |
| No. 60.—Sailing directions for Wrangell Strait, Alaska | 800 |
| No. 61.—Sailing directions for Inland Passage between Sitka Harbor and Hooniah Sound, through Olga Strait, Neva Strait, and Peril Straits, Alaska | 1,000 |
| No. 62.—Shoal developed near Marquesas Keys, Florida | 500 |
| APPENDICES TO THE REPORT FOR 1883. | |
| No. 6.—Descriptive Catalogue of Publications | 500 |
| No. 8.—The Estuary of the Delaware | 400 |
| No. 9.—Tides at Sandy Hook | 200 |
| No. 10.—Maxima and Minima Tide-Predicting Machine | 200 |
| No. 11.—On the length of the Yolo Base Line, California | 300 |
| No. 12.—Results for Atmospheric Refraction from Hypsometric measures made in California in 1880 | 500 |
| No. 13.—Report upon Magnetic Observations made at the U. S. Polar Station Ooglaamie, Point Barrow, Alaska, 1881–1882–1883 | 300 |
| No. 14.—Standard Topographical Drawings, First and second series | 500 |
| No. 15.—Transit of Mercury, November 7, 1881, observed at Yolo Base, California | 100 |
| No. 16.—The Transit of Venus, 1882 | 200 |
| No. 18.—Field Catalogue of Time and Circumpolar Stars for 1885 | 400 |
| No. 19.—Determinations of Gravity at stations in Pennsylvania, 1879–1880 | 300 |
| APPENDIX TO REPORT FOR 1884. | |
| No. 8.—The run of the Micrometer | 500 |

*Charts received in and issued from the Chart-room during the fiscal year ending June 30, 1885.*

| To whom issued. | Number of sheets— Received. | Issued. | On hand. July 1, 1884. | June 30, 1885. |
| --- | --- | --- | --- | --- |
| | 29,525 | | 35,876 | 36,496 |
| Executive Departments | | 10,740 | | |
| Senators and Representatives | | 1,423 | | |
| Institutions | | 927 | | |
| Sale Agents | | 14,035 | | |
| Foreign Governments | | 367 | | |
| Miscellaneous | | 1,413 | | |
| Total | 29,525 | 28,905 | 35,876 | 36,496 |

## *ARCHIVES AND LIBRARY U. S. COAST AND GEODETIC SURVEY OFFICE. REPORT FOR THE FISCAL YEAR ENDING JUNE 30, 1885.*

U. S. COAST AND GEODETIC SURVEY OFFICE,
*Washington, June* 30, 1885.

SIR: I respectfully submit herewith the annual report of the receipt and registry in the archives of all original and duplicate records and computations, original topographic and hydrographic sheets, and specimens of sea-bottom, turned into the Office during the fiscal year ending June 30, 1885. Also a report relating to the Library.

## I.—*Records and Computations.*

GEODETIC WORK.

| | Number of volumes. | | | |
|---|---|---|---|---|
| | Original. | Duplicate. | Computations. | Total. |
| Observations of Horizontal Angles | 147 | 115 | | 262 |
| Observations of Vertical Angles | 23 | 20 | | 43 |
| Descriptions of Stations | 16 | 11 | | 27 |
| Measurement of Bases | 5 | 2 | | 7 |
| Spirit-leveling | 49 | 44 | | 93 |
| Geodetic Miscellany | 22 | 20 | | 42 |
| Computations | | | 98 | 98 |
| Total | | | | 572 |

ASTRONOMICAL WORK.

| | | | | |
|---|---|---|---|---|
| Observations for Latitude | 7 | 2 | | 9 |
| Observations for Longitude | 1 | | | 1 |
| Observations for Time | 12 | 7 | | 19 |
| Observations for Azimuth | 9 | 2 | | 11 |
| Astronomical Miscellany | 3 | | | 3 |
| Computations | | | 37 | 37 |
| Total | | | | 80 |

MAGNETIC WORK.

| | | | | |
|---|---|---|---|---|
| Observations of Terrestrial Magnetism | 94 | 30 | | 124 |
| Computations | | | 15 | 15 |
| Total | | | | 139 |

HYDROGRAPHIC WORK.

| | | | | |
|---|---|---|---|---|
| Observations for Soundings | 257 | 121 | | 378 |
| Observations of Angles | 37 | 25 | | 62 |
| Descriptions of Hydrographic Signals | 5 | | | 5 |
| Specimens of Sea-bottom | 164 | | | 164 |
| Tidal Observations | 88 | 54 | | 142 |
| Total | | | | 751 |

## II.—*Topographic and Hydrographic Surveys.*

TOPOGRAPHIC WORK.

| | Number of sheets. | | Number of sheets. |
|---|---|---|---|
| Nestucca Bay and River, Oreg | 1 | Cherrystone Inlet, Va | 1 |
| Route of proposed Cape Cod Ship Canal, Mass | 1 | Walla Walla River, &c., W. T | 2 |
| New London and Vicinity, Conn | 1 | Fisherman's Bay to Walla Walla River, W. T | 1 |
| Hereford Inlet, N. J | 1 | | |
| Rondout and Harbor, N. Y | 2 | Total | 10 |

HYDROGRAPHIC WORK.

| | Number of sheets. | | Number of sheets. |
|---|---|---|---|
| Head of Narragangus Bay, Me | 2 | Nestucca Bay, Oreg | 1 |
| Shelter Island Sound, N. Y | 1 | Entrance Siuslaw River, Oreg | 1 |
| Little Neck Bay, N. Y | 1 | Gray's Harbor, Wash. Ter | 2 |
| Indian River, Fla | 2 | Long Island Sound, N. Y | 3 |
| Calcasieu Pass, La | 1 | West Coast of Florida | 4 |
| Monomoy Passage, Mass | 1 | Anclote River, Fla | 1 |
| Mud Hole Channel, Me | 1 | Lemon Bay, Fla | 2 |
| Black Rock Harbor, Conn | 1 | Hydrography of Louisiana and Texas | 3 |
| Hydrography off coast of Maine | 1 | Sabine Pass, Tex | 1 |
| Fisher's Island Sound, Conn | 2 | Guadalupe Island, Pacific Ocean | 1 |
| Approaches to New York Harbor | 2 | Temperature sections Gulf of Mexico | 5 |
| South Branch Elizabeth River, Va | 2 | Gedney and Swash Channels, N. Y | 1 |
| North River and Coanjock Cut, N. C | 1 | Stephen's Pass and Lynn Canal, Alaska | 2 |
| Examination Diamond Reef, N. Y | 1 | Chapin Point to Hatchet Point, L. I. Sound | 3 |
| Lower Delaware Bay, Del | 1 | Jupiter River and Inlet, Fla | 2 |
| Black Bay, Va. and N. C | 1 | Lakes Bocca Ratone and Wyman, Fla | 2 |
| Deep-sea Soundings East Bahama Banks | 1 | Pecho Point to Point Buchan, Cal | 2 |
| Grand Pass, La | 1 | | |
| Pacific Coast, Cal | 2 | Total | 61 |

The foregoing exhibit shows that there were registered in the archives during the past fiscal year 572 volumes of geodetic observations and computations; 80 volumes astronomical observations and computations; 139 volumes magnetic observations and computations; 751 volumes hydrographic observations and specimens of sea-bottom; 10 original topographic sheets, and 61 original hydrographic sheets—making a total in volumes, specimens, and sheets combined of 1,613.

On account of the absence of the regularly appointed Librarian by reason of severe illness, no full record was kept of the number of volumes received in the Library previous to December 19.

Since that date, however, an accurate registry has been made of all publications received, and they have been classified and arranged in their respective places. In all, including unbound and bound works, 477 volumes have been entered on the register.

There were prepared and sent out for binding 139 volumes, all of which were returned neatly and durably bound.

During the year many strayed books were recovered and returned. The entire library was rearranged, and a catalogue made, copies of which were furnished the Superintendent and Assistant in charge of Office.

The present condition of the Library, though susceptible of further improvement, is generally considered as being somewhat better than in years past.

The number of volumes taken out since December 10th is eight hundred and twenty-seven. A careful record has been kept of all such books, and their present whereabouts is accurately known.

Respectfully submitted.

T. D. REED,
*Custodian pro tem.*

Mr. B. A. COLONNA,
*Assistant in charge of Office.*

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*REPORT OF WORK DONE IN THE INSTRUMENT DIVISION DURING THE YEAR ENDING JUNE* 30, 1885.

COAST AND GEODETIC SURVEY OFFICE,
*Washington, September* 1, 1885.

DEAR SIR: I have the honor to submit the following report of the Instrument Division for the fiscal year ending June 30, 1885.

This report has been compiled from such data as were available, chiefly from the monthly reports, as the former Chief of the Division, who was in charge during the whole year, has been ved and is no longer connected with the office.

As heretofore the work of the Division has consisted mainly of repairs and readjustment of instruments turned in by the various field parties. Numerous old instruments have been improved, remodeled, and in some cases entirely reconstructed, and some new instruments, mainly minor ones, have been manufactured. The bulk of the new instruments required to meet the demand of the Survey have been purchased, as the manufacturing facilities of the office are limited and the force employed small.

All instruments returned from the field have been carefully examined and such repairs as were evidently needed and such improvements and alterations as were recommended by the field assistants have been made. Such parts as had become worn or broken were replaced and the instruments put in thorough order for future use.

The keeping of the records and the correspondence relating to the receiving and forwarding of instruments, &c., has also been attended to.

Mr. G. N. Saegmuller, when chief of the Division, supervised all the operations, and has personally attended to the regraduation of circles for theodolites and vertical circles and the limbs of sextants, &c., and the force of the instrument shop, viz, Messrs. John Clark, E. Eshleman, P. Vierbuchen, L. Fischer, and S. Kearney, have satisfactorily performed the duties assigned them.

Yours, respectfully,

ANDREW BRAID,
*Assistant.*

Mr. B. A. COLONNA,
*Assistant in charge of Office.*

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*REPORT OF THE OFFICE OF CONSTRUCTION OF STANDARD WEIGHTS AND MEASURES FOR THE FISCAL YEAR ENDING JUNE 30, 1885.*

U. S. COAST AND GEODETIC SURVEY,
*Office of Construction of Standard Weights and Measures, August 17, 1885.*

DEAR SIR: At your request I herewith respectfully submit a report of work done by those employed in the Office of Construction of Standard Weights and Measures for the fiscal year ending June 30, 1885.

James J. Clark, Adjuster, was detailed for duty at New Orleans, La., in care of the Coast and Geodetic Survey exhibit, and was consequently absent from this office from the 1st of December, 1884, till the 15th of June, 1885. The remaining portion of the fiscal year he was engaged in grinding six steel meters to length; compared yard of Yard and Meter No. 1 with British Bronze Yard No. 11; compared a set of weights and measures for New York City, and prepared the Weights and Measures exhibit for the New Orleans Exposition, and also determined the value of the abutting screw belonging to the Saxton Pyrometer No. 3. For a short time he was engaged in adjusting weights for Wyoming Territory, and attended to some of the official correspondence.

E. B. Lefavour, Verifier, was engaged in examining test-floats for specific gravity above 1,000, and tested salinometers; made computations of comparisons of decimeters on glass meter No. 1, also of yards Nos. 57 and 58, and glass meter No. 1 with brass meter No. 49; also computed Mr. Chapman's comparison of a pendulum with meter B; verified a set of weights for New York City; investigated expansion and point of maximum density of sea-water; investigated Densimeters for liquids heavier than water and tested evaporation and effect of meniscus; recorded observations for Mr. Chapman in the pendulum comparisons; adjusted two sets of brass weights for Washington Territory; verified a set of coin weights and set of grain weights for the Mint Bureau; adjusted two balances made by Fairbanks & Co. for Wyoming Territory; compared Yard of Yard and Meter brass bar No. 1 with British Bronze Yard No. 11; also determined the value of the United States Platinum Kilogramme (Arago), and attended to most of the correspondence.

D. C. Chapman, Mechanician, compared the Ohio State Yard with the standard; made ten sets of silver metric weights, six brass 25 and 50 grain weights; compared yard of Yard and Meter brass bar No. 1 with British Bronze Standard No. 11; compared two pendulums with meter B under the direction of Assistant C. S. Peirce; compared glass meter No. 1 with brass meter No. 49; compared glass decimeters Nos. 3 and 5 with each of the decimeters on glass meter No. 1; adjusted a set of capacity measures for New York City; compared the pendulum returned from the Greely Expedition with meter B; compared yard and foot scale of beam compass for the Washington Navy-Yard; adjusted two sets of capacity measures made by Troemner and Fairbanks, respectively, for Wyoming Territory; compared meter 49 with meter B; made set of coin weights, also set of grain weights for the Mint Bureau, and cleaned and made some new work for the two large balances belonging to the State of New Jersey, damaged by fire at the burning of the Capitol at Trenton.

Yours, respectfully,

JAS. J. CLARK,
*Adjuster and in Charge of Shop.*

B. A. COLONNA,
*Acting Superintendent Weights and Measures.*

# APPENDIX No. 5.

*REPORT OF THE HYDROGRAPHIC INSPECTOR FOR THE YEAR ENDING JUNE 30, 1885.*

U. S. COAST AND GEODETIC SURVEY OFFICE,
*Washington, July* 15, 1885.

DEAR SIR: I have the honor to make the following statement in relation to the branch of the Survey with which I have been connected for the past eight years, and of which I have had charge for nearly five years. This will constitute the annual report for the fiscal year ending June 30, 1885, and being my last I may be pardoned for touching on some topics which may seem foreign to the subject-matter.

The beginning of the fiscal year found most of the hydrographic parties preparing for work, which could not commence until after July 1, as has been usually the case during the past seven years with the limited appropriations made by Congress. As I have mentioned in previous reports, to get the most economical results, hydrographic work should begin on the Northern Coast as early as May 1, and can continue, as a rule, until the middle of October or 1st of November. The expenses of refitting the vessels and the principal items for keeping the parties at work are about the same for a long as a short season. It is, therefore, evident that with funds available for the months of July, August, and September only, the season is shortened about 50 per cent., and as the weather during September is generally unsettled, and a portion of July must be consumed in getting the vessels to their stations, the best portion of the season is lost by the delay.

In view of the apparent strong disinclination of Congress to increase the appropriations for party expenses, I would urge that a sufficient amount be retained out of the allotments for surveys on the Northern Coast for work during the last two months of each fiscal year so that it may be made continuous during the summer. I think this policy is particularly applicable to the resurvey of Long Island Sound, and it was with this object in view that I recommended the scheme approved by you for the present season. With only one schooner party (Lieut. S. C. Paine's, on the schooner Ready) on that work, but a small portion of the appropriation will be required this summer, and if sufficient is available next spring to put two schooners and one steamer on the survey, and for them to be allowed to continue under the appropriation for the fiscal year 1887, I anticipate the completion of the resurvey of Long Island Sound during the next fiscal year.

During the summer of 1884 there was engaged on the hydrography of the coast of Maine the schooner Eagre, with a party under charge of Lieut. E. D. F. Heald, U. S. N., Assistant Coast and Geodetic Survey.

A scheme which included some special examinations on this coast was prepared for the hydrographic party on board the steamer Blake, under charge of Lieut. Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey. Owing, however, to a delay in the construction of two new boilers for this vessel at Baltimore, the party did not get to work in time to take it up. Lieutenant-Commander Brownson was enabled, however, to make some important examinations in Vineyard Sound, Narragansett Bay, and Long Island Sound, which are specially mentioned in his report to you.

During the same period the schooner Palinurus, with a hydrographic party under charge of

Lieut. W. G. Cutler, U. S. N., Assistant Coast and Geodetic Survey, was engaged upon the resurvey of Long Island Sound. A larger hydrographic force than this was not necessary, as the hydrographic surveys were, at that time, well in advance of the topography, and could be prosecuted to better advantage after the points on which to base the work had been furnished by the civil assistants.

A small party on board the schooner Ready was sent into Long Island Sound under charge of Ensign A. F. Fechteler, U. S. N., Assistant Coast and Geodetic Survey, and made some special examinations, the small expense of the party being not much more to the survey than if the vessel had been laid up with her crew on broad. Later this party located a rock in Narragansett Bay, and still later made a survey of the shoals extending off Cape Henry, Va., upon which the U. S. S. Ossipee had struck, and which had been reported as of greater area than the published charts gave. The general contours were found to be about the same as given from the survey of 1855, and it appeared that the vessel when aground was on a shoal distinctly marked on the charts with 12 feet of water upon it.

The result of the season's work is detailed in the report made to you by the chief of party.

New York Harbor being a place of so much importance, and the changes on its bar, though slight, requiring frequent examinations to keep the mariner supplied with the latest information, it has been my endeavor to give some attention to it each year.

Since the complete resurvey of the bar made by Lieut. Commander E. B. Thomas, U. S. N., Assistant Coast and Geodetic Survey, in 1882, Congress has made no allowance until the present year for such work. In the summer of 1883, the schooner Drift having returned from work on the Southern Coast late in the season, and it being very desirable to keep this party intact for the winter's work, Lieut. J. C. Fremont, U. S. N., Assistant Coast and Geodetic Survey, the chief of party, was assigned to this field and obtained data for correcting the charts. Likewise, in 1884, considerable data were obtained for this purpose.

The steamer Bache, by reason of requiring new boilers, was left out of the general scheme for work during the summer season of 1884, but the perfectly organized party on board that vessel, as a matter of good public policy retained in the Survey on their naval pay, was used for this purpose. The chief of party, Lieut. H. B. Mansfield, U. S. N., Assistant Coast and Geodetic Survey, in anticipation of an assignment to a regular naval cruiser, was allowed leave, and I assumed the general charge of an examination of the main Ship and Swash Channels, which was well done by the party, under the immediate direction of Ensign J. M. Orchard, U. S. N , Assistant Coast and Geodetic Survey. The expenses of this work were practically little more than if the vessel had remained at the dock awaiting the completion of her boilers, while the results of the work enabled us to give to the public the latest changes, which are so necessary to the pilots of the large steamers entering the port of New York.

The party on board the steamer Endeavor, under charge of Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, was engaged upon the resurvey of Delaware Bay at its entrance. The result of the season's work is detailed in the report of Lieutenant Hanus. This completes the list of parties at work during the Summer.

During the Winter the steamer Bache, that had been placed under charge of Lieut. E. D. F. Heald, U. S. N., Assistant Coast and Geodetic Survey, on the detachment of Lieut. H. B. Mansfield, U. S. N., engaged upon an examination of a dredged channel in Mobile Bay; a survey around the Chandeleur Islands, off the coast of Louisiana, and in continuing the hydrography of the West Coast of Florida.

I would state here that the Survey, in losing the services of Lieutenant Mansfield, by reason of his detachment after a four years' tour of duty, lost one of the most valuable hydrographers with whom it has been my good fortune to be associated. Fertile in resources, thorough in his conception of the work, unassuming and pleasant to his subordinates, his party was always ready for his quietly-given instructions, and his abilities were fully equal to the execution of any work intrusted to him. It was only necessary to furnish him with projections and point out the field to be sure of good results. The Survey cannot too soon recall him to its work when his services shall become available.

Lieut. F. H. Crosby, U. S. N., after a short separation from the Survey as one of the officers sent to the relief of the Greely party, was in October again detailed by the Navy Department for the work, and assigned by you to the command of the steamer Gedney, in November. During the Winter he, with his party, made a survey of portions of Sabine and Calcasieu Lakes and the coast of Texas generally, as detailed in his report.

Lieut. G. C. Hanus, U. S. N., in charge of the party on board of the steamer Endeavor, laid up that vessel at Norfolk, Va., transferred his officers and a sufficient number of men to organize another party to the schooner Ready, and proceeded to Charleston, S. C. Here he turned over the Ready to the charge of Mr. Eugene Ellicott, Assistant Coast and Geodetic Survey, with the necessary men, and with his own party took charge of the steamer Arago, which had been left at that place in anticipation of the work required.

The Arago's party ran in the shore-line and made a hydrographic survey of a portion of Stono River and connections through to the Wadmelaw River, and then completed the hydrography of the Saint John's River from Racey Point to Buzzard Island. At the end of the season Lieutenant Hanus's party again joined the Ready and under charge of Ensign E. F. Leiper, U. S. N., Assistant Coast and Geodetic Survey, proceeded to New York and rejoined the Endeavor at that place, whither Lieutenant Hanus had preceded them to get the vessel ready for the resurvey of New York Harbor.

The steamer Blake, which for the past two years had been so ably commanded by Lieut. Commander W. H. Brownson, U. S. N., who was recalled by the Navy Department to regular Naval duties on board of a man-of-war, was fitted out for deep sea current observations, under charge of Lieut. J. E. Pillsbury, U. S. N. It might be proper here for me to place on record my appreciation of Lieut. Commander Brownson's services on the varied work of which he has been placed in charge while commander of the steamers Gedney and Blake. As, however, at the date of this report, he is again on duty in this office, having been selected by you as my successor in charge of the hydrography of the Coast and Geodetic Survey, it is hardly necessary to state more than that I feel proud of being relieved by an officer of his ability and experience.

No assignment to the command of the steamer Blake could, in my opinion, promise such good results as that of Lieut. J. E. Pillsbury, made by you on the detachment of Lieutenant Commander Brownson.

This officer's long experience as the Executive officer of this same vessel during which he frequently was called upon to take the chief command, his long familiarity with charts, his mechanical ingenuity, and his indomitable will cause me to feel the greatest confidence in the future of this scarcely developed but important branch of the Survey, viz, deep-sea currents. The end of the year finds us with most valuable data obtained by him with devices invented by himself during a season off the coast of Florida.

Overcoming difficulties that almost any one else would have regarded insurmountable, he has anchored the steamer Blake in the Gulf Stream in four or five hundred fathoms of water, remaining at anchor almost continuously for a complete lunar month, and while his records are not yet completed, the chief of the hydrological branch of the Survey, Prof. H. Mitchell, is enthusiastic in his commendations of the achievements of this party, and being so thoroughly interested in this part of the work, I myself feel that I cannot close this, my last report, without placing on record my strong admiration for the ability of Lieutenant Pillsbury.

Congress having in February passed the appropriation bill containing an item for the resurvey of New York Harbor, which should become immediately available, the office has been taxed to its utmost to obtain the number of proper officers to organize the four parties necessary for the work. Lieutenant Hanus, with his party, on the completion of the work in South Carolina and Florida, became available for one, and Lieut. W. G. Cutler, U. S. N., who had been in charge of the schooner Palinurus in the resurvey of Long Island Sound last summer, became available for the chief of a second party, and was placed on the work, again in charge of the Palinurus.

Lieut. John M. Hawley, U. S. N., who had served one tour of duty in the Survey before his last cruise in a man-of-war, fulfilled the requirements for a second tour and he was placed in charge of the party on board the schooner Eagre.

Lieut. F. S. Carter, U. S. N., having been detailed by the Department for Coast Survey duty was given charge of the schooner Drift, which was to be engaged on special current work, it being somewhat new to any one who might be employed.

The scheme prepared by myself and approved by you, made the following disposition of the parties: Lieutenant Hanus with the steamer Endeavor, one steam launch, and when necessary the steamer Daisy to survey the Entrance and main channels.

Lieutenant Hawley with his party on board the schooner Eagre, to which is attached one steam launch, to survey the East River from Governor's Island to the eastward.

Lieutenant Cutler with his party and a steam launch attached to the schooner Palinurus, was to survey in the North River, beginning at Governor's Island.

Lieutenant Carter on board the schooner Drift with a steam launch was to be associated with a party on board the schooner Scoresby, under Assistant H. L. Marindin, who was also supplied with a steam launch, on special current observations at first. Later it is proposed that the Drift's party should make current observations outside the entrance of New York Bay.

These parties, with the exception of the Drift, were in the field about the first of May, but were somewhat delayed on account of want of topographical data which could not then be furnished; still a very creditable commencement was made up to June 30. Of course this cannot be fully reported before its completion, and naturally comes in the next annual report of the Hydrographic Inspector.

Of the other vessels of the Survey not mentioned before in this report, I have to state that the steamer Hitchcock was used by the topographical party under Assistant F. W. Perkins, on the coast of Louisiana.

The barge Beauty was used by the topographical party under Assistant C. M. Bache during the summer of 1884 in the interior waters adjacent to the New Jersey coast. The schooner Quick was also in service in charge of Assistant Joseph Hergesheimer off the West coast of Florida.

The schooner Drift, on which was the hydrographic party under Ensign A. F. Fechteler, U. S. N., was taken to the eastern end of Long Island and used by the topographical party under charge of Assistant Charles Hosmer.

Of the remaining vessels, the steamer Barataria, schooners G. M. Bache, Silliman, and Research were laid up during the entire year. All of these vessels have about arrived at a point beyond which repairs become unprofitable, and as the Bache and Silliman could be used in an emergency, it might be well to retain them on the list, but I would recommend that the Research be sold as utterly useless. Through the recommendation of General Samuel B. Holabird, Quartermaster-General U. S. A., a very valuable addition has been made to the fleet of vessels by the transfer of the schooner Matchless from the War Department to the Coast and Geodetic Survey. While the transfer is in the nature of a loan, it is probable that the Survey may be possessed for a number of years to come of a very good schooner.

On recommendation of the Light-house Board, a very useful little vessel has been obtained by the transfer of the steamer Daisy. The vessel, though quite old, is, it is thought, good for several years' service in inside waters.

What has preceded refers to parties and vessels employed on the Atlantic Coast.

## PACIFIC COAST.

On the Pacific Coast much difficulty is experienced in executing hydrographic work, for not only is the coast a very difficult one to work upon, but the small appropriations permit only a small portion each year to be spent in actual field-work.

The repair and outfit of the vessels are at a cost almost double what it would be on this coast, while the wages of men are also much higher, as, for instance, a seaman in the Merchant service gets from $40 to $70 per month, in other branches of the Government service he receives about $40, while seamen on board Coast and Geodetic Survey vessels who are shipped on Naval Rolls receive only $24. This is made up to about $30 under the allowance for subsistence, but as the appropriations will permit it for only four or five months out of the year it can readily be seen that good men do not remain in the Survey for any length of time. At the same time this slight increase of pay adds very much to the expense of the work. A larger allotment for the work is the only remedy for this evil.

The passage of the steamer Patterson to the Pacific Coast from New York has been made the subject of a special report to you, but notwithstanding the long passage, under Lieut. R. Clover's able management, she was equipped at San Francisco and was well under way with the work on the Coast of Alaska in the early part of the season. To my mind this is the most important field for surveying which is left to the service, and I cannot too strongly urge the importance of a liberal allotment of money, and the detail of an officer in charge who will have, like the Patterson's present commander, the highest attainments as a surveyor. It is needless to say that the interest I have had in this vessel and her work from its inception, will not lessen after my detachment from the Survey.

The steamer Hassler was engaged with the party under the direction of Lieut. Commander. A. S. Snow, U. S. N. Assistant Coast and Geodetic Survey during the Summer of 1884, on the hydrography of the Straits of Fuca. I cannot commend too highly the energy and intelligence of this officer, whose management of his party has won my strongest approbation and the highest commendations of all members of the Survey who have come in contact with him.

The party on board the steamer McArthur under the charge of Lieut. E. D. Taussig, U. S. N., Assistant Coast and Geodetic Survey, has had much to contend with in the field of operations on the coast of California, owing to the small and dangerous character of the harbors.

The meager appropriations have also been a cause of delay, but the chief of party has generally overcome the difficulties and transmitted to the office data, in quality unexcelled by any I have seen from that coast, and equaled by that from very few parties, while the quantity was very creditable indeed for the amount of money allotted for the work.

The schooner Earnest started a very promising season's work in Puget Sound at the commencement of the year, which came to an abrupt termination about the middle of July, by your telegraphic instructions to discontinue the survey on account of lack of appropriations.

The schooner Yukon has been used on topographic work with the party under Assistant J. F. Pratt.

The changes which have taken place among the Naval officers attached to the Survey are indicated in a statement appended to this report. I also append a roster of the officers with their stations on June 30, 1885, a list of names of vessels, their tonnage, &c., in the service of the Survey during the fiscal year, and tabular statements showing the whole number of naval officers on duty at different periods during the year, and the number of men attached to the vessels of the Survey during each quarter of the fiscal year.

## REPAIRS OF VESSELS.

The repairs and maintenance of the complement of vessels have been made easier this year than usual by the extra allotment in the appropriation made by Congress of $12,000 for new boilers to the steamer Hassler. I have given in previous reports the general condition of the vessels belonging to the Survey, thus making it unnecessary to do more than summarize the matter here. I will therefore make a table of the amounts expended, and state as follows:

The steamers Hassler, Blake, and Bache have new boilers, and with these large items provided for, the larger vessels of the Survey are believed to be in good condition for service for several years to come. An exception might be made to this in the case of the steamer Blake, which got severely strained while aground on the Saint John's River bar some years ago; and as she has leaked more or less ever since, it may be necessary to make extensive repairs to her hull before long.

I think I can safely say, as a rule, that, excepting the vessels which have been before mentioned as worn out, the vessels of the Survey are in better condition than they were four years ago. It will, however, be a difficult matter to provide for the ordinary wear and tear, particularly now that the Patterson, the largest vessel of the fleet, has been added to the list, on the appropriation passed by Congress for the present fiscal year. The very least that should be estimated for is that sum to which the appropriation was reduced in 1878, and below which it has never been until the present fiscal year, viz, $30,000.

## OFFICE-WORK.

The general office-work has progressed, as usual, to my entire satisfaction, the results being presented in the tabulated records appended to this report, of work done by Messrs. Eugene Willenbücher, W. C. Willenbücher, and F. C. Donn. I may be permitted here, as I am about to sever my connection with the Survey, to submit some remarks in relation to the office of the Hydrographic Inspector, as the matter affects others, and, I believe, the service in general, whose interest alone I have attempted to study during the past eight years of my life.

As I understand, the duties of the Hydrographic Inspector, and which, from my numerous interviews with you, I am led to believe accord with your views, are as follows: He is in charge of the details of all hydrographic work, acting as the chief adviser and executive officer of the Superintendent in hydrography; being responsible to him for the proper execution of all his instructions in relation to hydrographic matters, in the same manner as the Assistant in charge of Office and Topography is responsible to him in matters pertaining to the office and topography. As the Inspector of Hydrography and as in charge of the repairs and maintenance of the vessels of the Survey, his duties are in the field as well as in the office, and among the vessels, with a view to harmonizing all the work of the various hydrographic parties, and to obtain the best results in the repairing of vessels that his experience and the Superintendent's allotments may suggest. He is at the same time in charge of the Hydrographic office, which embraces the Hydrographic Division and the Coast Pilot Division. I have endeavored to carry out this, my interpretation of the Superintendent's various discussions, and I believe that in most cases some benefit has accrued to the harmony of the various branches of the work.

I have been extremely fortunate in having associated with me in the office the best men that have graduated from the Survey under previous assignments. The Coast Pilot work met with a loss when, in December last, Lieut. J. E. Pillsbury was assigned to the command of the steamer Blake, but in the end, the service will gain by his transfer to that command.

Partly from sickness during the past year, more on account of necessary absence from the office on duty, but principally from my sense of what was due the ability of that officer, I have gradually turned all the details of the Hydrographic Division over to Lieut. Jeff. F. Moser, U. S. N., Assistant Coast and Geodetic Survey, in whose hands the very best results possible will be obtained. The Survey will never suffer for want of a strong man (with the most liberal construction that can be placed on the word) for any position in the service as long as he is available for its work.

Mr. Edward H. Wyvill has, as usual, given valuable assistance as my clerk.

I cannot close this, my last report, without expressing my warmest personal obligations for the many acts of courtesy I have received from nearly every member of the Survey, from the Superintendent down, and my interest will ever center in work which to me has so many pleasant associations.

Very respectfully,

C. M. CHESTER,
*Commander, U. S. Navy,*
*Hydrographic Inspector Coast and Geodetic Survey.*

Prof. J. E. HILGARD,
*Superintendent U. S. Coast and Geodetic Survey.*

*Hydrographic sheets plotted, verified, and inked during the fiscal year ending June 30, 1885.*

| Titles of sheets. | Scale. | Draughtsmen. | Remarks. |
|---|---|---|---|
| ATLANTIC COAST. | | | |
| Narraguagus Bay Entrance, Me | 1-10,000 | Eugene Willenbucher | Protracted, plotted, and drawn. |
| Narraguagus River, above Millbridge, Me | 1-10,000 | do | Plotted and drawn. |
| Harrington Bay and River, Me | 1-10,000 | do | Do. |
| Pleasant Bay, Me | 1-10,000 | do | Do. |
| L'Homme Dieu Shoal, &c., Mass | 1-10,000 | F. C. Donn | Protracted, plotted, and drawn. |
| Off Point Judith, R. I | 1-10,000 | W. C. Willenbucher | Plotted and drawn. |
| Long Island Sound, Race Rock to Plum Gut | 1-20,000 | Eugene Willenbucher | Do. |
| Long Island Sound, Plum Gut to Inlet Point | 1-20,000 | do | Do. |
| Long Island Sound, Inlet Point to Old Landing | 1-40,000 | do | Do. |
| Long Island Sound, Chapin Point to Hatchet Point | 1-10,000 | F. C. Donn | Do. |
| Long Island Sound, Hatchet Point to Cornfield Point | 1-10,000 | do | Do. |
| Long Island Sound, Cornfield Point to Hammonasett Point | 1-10,000 | do | Do. |
| Long Island Sound, Hammonasett Point to Sachem's Head | 1-10,000 | W. C. Willenbucher | Do. |
| Long Island Sound, Sachem's Head to Negro Heads | 1-10,000 | do | Do. |
| Long Island Sound, Chapin Point to Bartlett's Reef | 1-10,000 | Eugene Willenbucher | Do. |
| Dimond Reef, New York Harbor | 1-5,000 | do | Protracted, plotted, drawn. |
| Gedney and Swash Channels, New York Lower Bay | 1-10,000 | W. C. Willenbucher | Do. |
| Approaches to Delaware Bay | 1-40,000 | Eugene Willenbucher | Plotted and drawn. |
| Delaware Bay, Broadkill to Mispillion Creek | 1-20,000 | do | Do. |
| Delaware Bay, Jones' Creek to Mahon's River | 1-20,000 | W. C. Willenbucher | Do. |
| Back Bay, N. C | 1-20,000 | do | Do. |
| Jupiter River, Hole Sound, &c., Fla | 1-5,000 | do | Do. |
| Lake Worth, Fla | 1-40,000 | do | Do. |
| Lake Boca Ratone, Hillsboro River, &c., Fla | 1-10,000 | do | Do. |
| Southern part of New River, and Head of Key Biscayne Bay | 1-20,000 | do | Do. |
| South of San Carlos, Fla. (Sheet No. 1) | 1-40,000 | Eugene Willenbucher | Do. |
| South of San Carlos, Fla. (Sheet No. 2) | 1-40,000 | do | Do. |
| Lemon Bay, Fla., Bocilla Inlet to Stump Pass | 1-20,000 | do | Do. |
| Lemon Bay, Fla., Stump Pass to head of Bay | 1-20,000 | do | Do. |
| Saint Joseph's Bay and approaches, Fla. (Sheet No. 1) | 1-40,000 | do | Do. |
| Saint Joseph's Bay and approaches, Fla. (Sheet No. 2) | 1-40,000 | do | Do. |
| Anclote River, Fla | 1-10,000 | do | Do. |
| Grand Pass, Mississippi River, La | 1-30,000 | W. C. Willenbucher | Do. |
| Off coast of Louisiana and Texas | 1-80,000 | do | Do. |
| Sabine Pass, La. and Tex | 1-20,000 | do | Do. |
| Outer Bar, Galveston Entrance, Tex | 1-10,000 | do | Do. |
| South of Galveston, Tex | 1-80,000 | do | Do. |
| North Atlantic Ocean | 1-1,200,000 | Eugene Willenbucher | Do. |
| PACIFIC COAST. | | | |
| Pecho Point to Buchon Point, Cal | 1-10,000 | F. C. Donn | Verified, inked, and finished |
| Buchon Point to Beach Point, Cal | 1-10,000 | do | Do. |
| Beach Point to Moro Rock, Cal | 1-10,000 | do | Do. |
| Moro Rock to Point △, Cal | 1-10,000 | do | Do. |
| Pice House to Castro △, Cal | 1-10,000 | do | Do. |
| Castro △ to Breaker Point, Cal | 1-10,000 | do | Do. |
| Breaker Point to northward, Cal | 1-10,000 | do | Do. |
| Salmon Point to Point Cabrillo, Cal | 1-20,000 | do | Do. |
| Point Cabrillo to Brushy Point, Cal | 1-20,000 | do | Do. |
| Nestucca Bay, Oregon | 1-10,000 | W. C. Willenbucher | Plotted and drawn. |
| Siuslaw River Entrance, Oregon | 1-10,000 | do | Do. |
| Gray's Harbor, entrance, W. T | 1-20,000 | do | Verified, inked, and finished. |
| Gray's Harbor, upper part, W. T | 1-20,000 | do | Do. |
| Junction of Stephen's Passage and Lynn Canal, Alaska | 1-40,000 | Eugene Willenbucher | Compilation. |
| Bartlett Cove, Alaska | 1-20,000 | do | Do. |
| Leo Anchorage, Alaska | 1-20,000 | do | Do. |
| Peril Strait, from Point Sulvia to Nismen Point, Alaska | 1-20,000 | do | Do. |
| Inland Passage, Peril Strait to Sitka Harbor | 1-20,000 | do | Do. |
| Wrangell Strait, Alaska | 1-20,000 | do | Do. |
| Southeast Alaska, Revilla Gigedo Channel, 12 sheets | Various. | F. C. Donn | Finishing. |

*Hydrographic sheets plotted, verified, and inked during the fiscal year ending June 30, 1885—Cont'd.*

| Titles of sheets. | Scale. | Draughtsmen. | Remarks. |
|---|---|---|---|
| MISCELLANEOUS. | | | |
| Plan of steamer Hassler | | F. C. Donn | Tracing. |
| Deep-sea soundings (2,505) | | Eugene Willenbucher | Plotted by latitude and longitude. |
| Temperature stations (306) | | do | Do. |
| Current stations (28) | | do | Do. |
| 41 Tracings for Hydrographic parties, Light-House Board, &c | | W. C. Willenbucher | Tracings. |
| Projects for charts Nos. 714, 715, 727, and 728 | | Eugene Willenbucher | |
| One projection, Dimond Reef | 1-5,000 | do | |
| Two projections | 1-20,000 | do | |
| Steamer Patterson | | F. C. Donn | Tracing for photolithograph. |
| Steamer Patterson, curves of stability | | do | Do. |
| Steamer Patterson, area, moment curves, &c | | do | Do. |
| Steamer Bache and others | | do | Tracing and comparisons. |
| Moon's Declination | | do | Copying curves, &c. |
| Additional hydrography, plotted on four original sheets | | do | Protracted, plotted, and drawn. |
| Additional hydrography, plotted on 17 original sheets | | W. C. Willenbucher | Do. |
| Progress sketch, coast of Maine | 1-10,000 | do | Drawn. |

*Verification and correction of reduced Drawings of Hydrography for fiscal year ending June 30, 1885.*

| Catalogue number of Charts. | Title of Charts. | Scale. | Draughtsman. |
|---|---|---|---|
| C | Gulf of Mexico | 1-1,200,000 | Eugene Willenbucher. |
| 14 | Cape Canaveral to Fowey Rocks | 1-400,000 | Do. |
| 15 | Straits of Florida | 1-400,000 | Do. |
| 16 | Key West to Tampa Bay | 1-400,000 | Do. |
| 103 | Mount Desert Island, &c | 1-80,000 | Do. |
| 120 | New York Bay and Harbor | 1-80,000 | Do. |
| 121 | Sandy Hook to Barnegat | 1-80,000 | Do. |
| 140 | Albemarle Sound (eastern sheet) | 1-80,000 | Do. |
| 131 | Entrance to Chesapeake Bay | 1-80,000 | Do. |
| 147 | Coast chart 47 | 1-80,000 | Do. |
| 148 | Coast chart 48 | 1-80,000 | Do. |
| 152 | Coast chart 52 | 1-80,000 | Do. |
| 153 | Winyah Bay to Long Island | 1-80,000 | Do. |
| 175 | San Carlos Bay to Lemon Bay | 1-80,000 | Do. |
| 176 | Lemon Bay to Tampa Bay | 1-80,000 | Do. |
| 177 | Tampa Bay | 1-80,000 | Do. |
| 439 | Calibogue Sound and Skull Creek | 1-80,000 | Do. |
| 440 | Savannah River and Wassaw Sound | 1-80,000 | Do. |
| 621a | San Francisco Entrance | 1-80,000 | Do. |
| 650 | Port Gamble | 1-20,000 | Do. |
| 673 | Point Concepcion to San Luis Obispo | 1-200,000 | Do. |
| 710 | Revilla Gigedo Channel | 1-200,000 | Do. |
| 712a | Harbors Revilla Gigedo Channel | Various. | Do. |
| 714 | Wrangell Strait, Port Wrangell, &c | 1-40,000 | Do. |
| 715 | Anchorages in Southeast Alaska | Various. | Do. |
| 727 | Inland passage between Sitka and Hooniah Sound | 1-40,000 | Do. |
| 728 | Junction of Stephen's Passage and Lynn Canal | 1-80,000 | Do. |

*Charts for which reduced drawings of hydrography were made during the fiscal year ending June 30, 1885.*

| Catalogue number of charts. | Title of Charts. | Scale. | Draughtsmen. |
|---|---|---|---|
| A | Cape Sable to Cape Hatteras | 1-1, 200, 000 | Eugene Willenbucher. |
| B | Cape Hatteras to Key West | 1-1, 200, 000 | Do. |
| C | Gulf of Mexico | 1-1, 200, 000 | Do. |
| C | Do | 1-1, 200, 000 | W. C. Willenbucher. |
| D | Do | 1-2, 100, 000 | Eugene Willenbucher. |
| 10 | Cape Henry to Cape Lookout | 1-400, 000 | W. C. Willenbucher. |
| 14 | Cape Canaveral to Fowey Rocks | 1-400, 000 | Do. |
| 14 | Do | 1-400, 000 | Eugene Willenbucher. |
| 103 | Coast chart No. 3 | 1-80, 000 | Do. |
| 103 | Do | 1-80, 000 | W. C. Willenbucher. |
| 104 | Penobscot Bay | 1-80, 000 | Do. |
| 105 | Penobscot Bay to Kennebec Entrance | 1-80, 000 | Do. |
| 106 | Kennebec Entrance to Saco River | 1-80, 000 | Do. |
| 112 | Monomoy to Block Island (Middle sheet) | 1-80, 000 | F. C. Donn. |
| 113 | Monomoy to Block Island (Western sheet) | 1-80, 000 | Do. |
| 113 | Monomoy to Block Island (Western sheet) | 1-80, 000 | W. C. Willenbucher. |
| 114 | Long Island Sound (Eastern sheet) | 1-80, 000 | Do. |
| 115 | Long Island Sound (Middle sheet) | 1-80, 000 | Do. |
| 120 | New York Bay and Harbor | 1-80, 000 | Do. |
| 124 | Delaware Bay (Lower sheet) | 1-80, 000 | Do. |
| 125 | Delaware Bay (Middle sheet) | 1-80, 000 | Do. |
| 137 | Cape Henry to Currituck Beach | 1-80, 000 | Do. |
| 142 | Pamplico Sound (Sheet No. 1) | 1-80, 000 | Do. |
| 143 | Pamplico Sound (Sheet No. 2) | 1-80, 000 | Do. |
| 156 | Savannah to Sapelo Island | 1-80, 000 | Eugene Willenbucher. |
| 170 | Key West to Rebecca Shoal | 1-80, 000 | W. C. Willenbucher. |
| 307 | Blue Hill Bay, &c | 1-40, 000 | Do. |
| 358 | Narragansett Bay | 1-40, 000 | Do. |
| 353 | Do | 1-40, 000 | F. C. Donn. |
| 362 | New Haven Harbor | 1-20, 000 | W. C. Willenbucher. |
| 369 | New York Bay and Harbor | 1-40, 000 | Do. |
| 369[a] | New York Entrance | 1-40, 000 | Do. |
| 675 | Point Pinos to Bodega Head | 1-200, 000 | Do. |
| 676 | San Francisco to Point Arena | 1-200, 000 | Do. |
| 960 | Alaska and adjacent Territory | 1-3, 500, 000 | Eugene Willenbucher. |

*List of Naval officers attached to Coast and Geodetic Survey during fiscal year ending June 30, 1885.*

| Name. | Date attached. | Remarks. |
|---|---|---|
| COMMANDERS. | | |
| C. M. Chester | Oct. 2, 1877 | Still in service. |
| LIEUTENANT-COMMANDERS. | | |
| A. S. Snow | Aug. 1, 1883 | Still in service. |
| W. H. Brownson | Aug. 11, 1881 | Detached December 2, 1884; re-attached June 29, 1885. |
| H. E. Nichols | Jan. 22, 1879 | Detached July 31, 1884. |
| LIEUTENANTS. | | |
| J. T. Sullivan | Nov. 21, 1882 | |
| H. B. Mansfield | Feb. 28, 1881 | |
| E. D. F. Heald | Mar. 23, 1882 | Still in service. |
| Richardson Clover | July 26, 1881 | Do. |
| E. D. Taussig | Apr. 30, 1883 | Do. |
| LIEUTENANTS—Cont'd. | | |
| J. E. Pillsbury | July 13, 1882 | Still in service. |
| Jeff. F. Moser | Jan. 29, 1884 | Do. |
| Charles F. Forse | July 7, 1884 | Do. |
| J. M. Hawley | Mar. 21, 1885 | Do. |
| G. Blocklinger | Jan. 30, 1883 | Do. |
| S. C. Paine | June 2, 1885 | Do. |
| F. H. Crosby | Oct. 6, 1884 | Do. |
| G. C. Hanus | Mar. 20, 1883 | Do. |
| F. H. Lefavor | Sept. 6, 1882 | |
| J. C. Fremont | May 21, 1881 | |
| LIEUTENANTS, JUNIOR GRADE. | | |
| C. McR. Winslow | Aug. 16, 1881 | |
| George H. Peters | June 30, 1885 | Still in service. |

*List of Naval officers attached to Coast and Geodetic Survey, &c.*—Continued.

| Name. | Date attached. | Remarks. |
|---|---|---|
| LIEUTENANTS, JUNIOR GRADE—Cont'd. | | |
| J. M. Helm | Feb. 13, 1885 | Still in service. |
| W. G. Cutler | Mar. 29, 1883 | Do. |
| F. S. Carter | Apr. 23, 1885 | Do. |
| ENSIGNS. | | |
| W. McLean | July 15, 1884 | Still in service. |
| T. D. Griffin | May 2, 1883 | Do. |
| F. H. Sherman | Oct. 31, 1882 | Do. |
| J. M. Orchard | Feb. 10, 1882 | Do. |
| J. N. Jordan | Jan. 25, 1881 | Do. |
| J. P. Parker | Mar. 5, 1883 | Detached September 30, 1884. |
| A. F. Fechteler | June 24, 1882 | Still in service. |
| F. M. Brumby | Dec. 21, 1882 | Do. |
| E. E. Wright | Apr. 7, 1885 | Do. |
| A. W. Dodd | Apr. 9, 1885 | Do. |
| Alfred Jeffries | July 17, 1882 | Detached June 15, 1885. |
| W. V. Bronaugh | Aug. 12, 1881 | Detached November 30, 1884. |
| F. M. Bostwick | Sept. 28, 1881 | Still in service. |
| A. L. Hall | May 1, 1883 | Do. |
| P. J. Werlich | Mar. 15, 1884 | Do. |
| W. L. Burdick | Mar. 31, 1884 | Do. |
| P. B. Bibb | Nov. 30, 1882 | Detached July 28, 1884. |
| W. C. Canfield | Sept. 26, 1882 | Still in service. |
| A. G. Rogers | Apr. 29, 1885 | Do. |
| W. P. White | Feb. 10, 1883 | Do. |
| John H. Shipley | Apr. 17, 1885 | Do. |
| John E. Craven | Nov. 28, 1883 | Do. |
| J. H. Hetherington | June 19, 1883 | Do. |
| C. C. Marsh | May 3, 1884 | Do. |
| C. W. Jungen | Aug. 25, 1883 | Do. |
| R. P. Schwerin | May 3, 1883 | Detached July 11, 1884. |
| C. S. Ripley | May 4, 1885 | Still in service. |
| W. J. Sears | Apr. 28, 1885 | Do. |
| J. A. Bell | Feb. 22, 1885 | Do. |
| D. P. Menefee | July 28, 1883 | Do. |
| F. W. Kellogg | Aug. 23, 1882 | Do. |
| W. A. Thom | Nov. 1, 1884 | Do. |
| R. O. Bitler | Apr. 29, 1885 | Do. |
| Harry Phelps | June 30, 1883 | Detached September 30, 1884. |
| LIEUTENANTS, JUNIOR GRADE—Cont'd. | | |
| A. P. Niblack | July 2, 1884 | Still in service. |
| William Truxtun | July 3, 1882 | Do. |
| E. Simpson, jr | Oct. 21, 1882 | Do. |
| J. H. Watters | July 7, 1883 | Do. |
| E. F. Leiper | Apr. 26, 1883 | Do. |
| M. C. Gorgas | Oct. 26, 1882 | Do. |
| F. R. Brainard | July 20, 1883 | Do. |
| T. G. Dewey | June 18, 1883 | Do. |
| G. R. French | May 4, 1883 | Do. |
| F. A. McNutt | Oct. 15, 1884 | Do. |
| SURGEONS. | | |
| W. S. Dixon | Apr. 20, 1884 | Still in service. |
| PASSED ASSISTANT SURGEONS. | | |
| F. H. Streets | Mar. 19, 1884 | Still in service. |
| E. Y. Derr | Sept. 7, 1881 | Detached September 1, 1884. |
| F. B. Stephenson | Sept. 1, 1884 | Still in service. |
| W. H. Rush | June 3, 1884 | Do. |
| ASSISTANT SURGEONS. | | |
| H. B. Fitts | Jan. 27, 1884 | Still in service. |
| PASSED ASSISTANT PAYMASTER. | | |
| J. R. Stanton | Nov. 1, 1883 | Still in service. |
| PASSED ASSISTANT ENGINEERS. | | |
| H. Main | May 29, 1883 | Still in service. |
| H. N. Stevenson | Mar. 10, 1883 | Do. |
| G. H. Kearney | Oct. 5, 1881 | Detached January 1, 1885. |
| George Cowie, jr | Jan. 1, 1885 | Still in service. |
| N. N. Leitch | Jan. 14, 1885 | Detached January 19, 1885. |
| R. W. Galt | Nov. 26, 1879 | Detached November 15, 1884. |
| ASSISTANT ENGINEERS. | | |
| William N. Little | Nov. 15, 1884 | Detached January 13, 1885. |
| E. T. Warburton | Feb. 24, 1883 | Still in service. |
| R. I. Reid | June 19, 1882 | Do. |

*List of Naval Officers attached to Coast and Geodetic Survey, June* 30, 1885.

Commander C. M. Chester, Hydrographic Inspector.
Lieut. Commander W. H. Brownson, Coast and Geodetic Survey Office.
Lieut. Jeff. F. Moser, Coast and Geodetic Survey Office.
Lieut. George H. Peters, Coast and Geodetic Survey Office.
Passed Assistant Paymaster J. R. Stanton, Coast and Geodetic Survey Office.

### ATLANTIC AND GULF COASTS.

*Steamer A. D. Bache* (Atlantic Coast).—Lieut. E. D. F. Heald, Commanding; Ensigns, J. M. Orchard, W. C. Canfield, John E. Craven, and W. J. Sears; Passed Assistant Surgeon, F. B. Stephenson; Passed Assistant Engineer, Herschel Main.

*Steamer G. S. Blake* (Atlantic Coast).—Lieut. John E. Pillsbury, Commanding; Ensigns, A F. Fechteler, P. J. Werlich, William A. Thom, William Truxton, E. Simpson, jr., and Miles Gorgas; Passed Assistant Surgeon, William H. Rush; Passed Assistant Engineer, George Cowie, jr.

*Schooner Eagre* (Atlantic Coast).—Lieut. John M. Hawley, Commanding; Ensigns, F. H. Sherman, A. W. Dodd, and R. O. Bitler.

*Schooner Ready* (Atlantic Coast).—Lieut. Sumner C. Paine, Commanding; Ensign, T. D. Griffin.

*Steamer Gedney* (Atlantic Coast).—Lieut. Freeman H. Crosby, Commanding; Ensigns, T. M. Brumby, A. L. Hall, John H. Hetherington, F. W. Kellogg, and J. S. Watters; Assistant Surgeon, Henry B. Fitts.

*Steamer Endeavor* (Atlantic Coast).—Lieut. G. C. Hanus, Commanding; Ensigns, Charles S. Ripley, Edward F. Leiper, F. R. Brainard, and George R. French.

*Schooner Palinurus* (Atlantic Coast).—Lieut. William G. Cutler, Commanding; Ensigns, E. M. Wright and A. G. Rogers.

*Schooner Drift* (Atlantic Coast).—Lieut. Fidelio S. Carter, Commanding.

PACIFIC COAST.

*Steamer Hassler* (Pacific Coast).—Lieut. Commander A. S. Snow, Commanding; Lieut. G. Blocklinger; Ensigns, F. M. Bostwick, W. P. White, J. H. Shipley, and C. W. Jungen; Surgeon, William S. Dixon; Assistant Engineer, E. T. Warburton.

*Steamer Patterson* (Alaska Coast).—Lieut. Richardson Clover, Commanding; Lieut. James M. Helm; Ensigns, W. McLean, C. C. Marsh, D. P. Menefee, A. P. Niblack, and T. G. Dewey; Passed Assistant Surgeon, Thomas H. Streets; Passed Assistant Engineer, H. N. Stevenson.

*Steamer McArthur* (Pacific Coast).—Lieut. Edward D. Taussig, Commanding; Ensigns, William L. Burdick, John A. Bell, and F. A. McNutt; Assistant Engineer, R. I. Reid.

*Schooner Earnest* (Pacific Coast).—Lieut. Charles T. Forse, Commanding; Ensign, J. N. Jordan.

*Names of vessels, their tonnage, &c., in the service of the Coast and Geodetic Survey, during the fiscal year ending June* 30, 1885.

| No. | Name of vessel. | Tonnage. | Complement of— Officers. | Men. |
|---|---|---|---|---|
| 1 | Steamer Carlile P. Patterson | 453 | 9 | 36 |
| 2 | Steamer Hassler | 243 | 9 | 34 |
| 3 | Steamer Blake | 218 | 8 | 36 |
| 4 | Steamer Bache | 186 | 7 | 33 |
| 5 | Steamer Gedney | 133 | 7 | 29 |
| 6 | Steamer McArthur | 112 | 7 | 29 |
| 7 | Steamer Endeavor | 105 | 5 | 17 |
| 8 | Steamer Hitchcock (civilian party) | 83 | | |
| 9 | Steamer Barataria (laid up) | 50 | | |
| 10 | Steamer Arago | 38 | 3 | 15 |
| 11 | Steamer Daisy | 44 | | |
| 1 | Schooner Eagre | 202 | 4 | 18 |
| 2 | Schooner Drift | 87 | 4 | 14 |
| 3 | Schooner Earnest | 80 | 2 | 12 |
| 4 | Schooner Ready | 80 | 3 | 14 |
| 5 | Schooner Yukon (civilian party) | 78 | | |
| 6 | Schooner Research (laid up) | 76 | | |
| 7 | Schooner Palinurus | 76 | 3 | 14 |
| 8 | Schooner Silliman (laid up) | 72 | | |
| 9 | Schooner Scoresby (civilian party) | 72 | | |
| 10 | Schooner Matchless (laid up) | | | |
| 11 | Schooner G. M. Bache (laid up) | 46 | | |
| 12 | Schooner Quick (civilian party) | 38 | | |
| 1 | Sloop Kincheloe (civilian party) | 30 | | |
| 1 | Barge Beauty (civilian party) | 28 | | |

RECAPITULATION.

| | |
|---|---|
| **Whole number of vessels:** | |
| Steamers | 11 |
| Schooners | 12 |
| Sloops | 1 |
| Barges | 1 |
| Total | 25 |
| **Number of vessels in active service** | 19 |

This complement does not represent the actual number of officers or of men in the Survey during the year, owing to the fact that some vessels were employed only a part of the time.

Average number of officers for the year .......... .... .................... 54
Average number of men for the year ............... .......... ... ....... 280

See tabular statements appended showing actual number of officers attached to the several vessels in service and number of officers on other duty at different periods during the fiscal year; also the number of men actually in service at the end of each quarter of the fiscal year, with the names of the vessels in which they were serving.

*Number of naval officers attached to Coast and Geodetic Survey vessels for fiscal year ending June* 30, 1885.

| Name of vessel. | September 30, 1884. | March 31, 1885. | Name of vessel. | September 30, 1884. | March 31, 1885. |
|---|---|---|---|---|---|
| Steamer Blake | 7 | 9 | Steamer McArthur | 3 | 6 |
| Steamer Bache | 4 | 8 | Schooner Eagre | 4 | 2 |
| Steamer Gedney | 2 | 7 | Schooner Ready | 3 | 3 |
| Steamer Endeavor | 4 | ........ | Schooner Palinurus | 3 | 1 |
| Steamer Arago | .......... | 1 | Schooner Earnest | 2 | 1 |
| Steamer C. P. Patterson | 9 | 9 | Coast Survey Office | 3 | 3 |
| Steamer Hassler | 7 | 7 | Total | 51 | 57 |

Average number, 51.

*Number of men attached to Coast and Geodetic Survey vessels for fiscal year ending June* 30, 1885.

| Name of vessel. | For quarter ending— | | | |
|---|---|---|---|---|
| | September 30, 1884. | December 31, 1884. | March 31, 1885. | June 30, 1885. |
| Steamer Blake | 35 | 35 | 39 | 36 |
| Steamer Bache | 31 | 31 | 33 | 28 |
| Steamer Gedney | 24 | 27 | 27 | 25 |
| Steamer Endeavor | 17 | 17 | 8 | 20 |
| Steamer Arago | .......... | .......... | 14 | .......... |
| Steamer Daisy | .......... | .......... | .......... | 8 |
| Steamer Hassler | 34 | 33 | 33 | 31 |
| Steamer C. P. Patterson | 38 | 39 | 37 | 38 |
| Steamer McArthur | 28 | 27 | 29 | 29 |
| Schooner Eagre | 19 | 8 | 12 | 17 |
| Schooner Palinurus | 15 | 5 | 15 | 15 |
| Schooner Drift | .......... | .......... | 9 | 14 |
| Schooner Ready | 15 | 14 | .......... | 16 |
| Schooner Earnest | 8 | 8 | 8 | 15 |
| Vessels laid up | 15 | 16 | 11 | 14 |
| Total | 279 | 260 | 275 | 306 |

Average number, 280.

# APPENDIX No. 6.

## THE GEOGRAPHICAL DISTRIBUTION AND SECULAR VARIATION OF THE MAGNETIC DIP AND INTENSITY IN THE UNITED STATES.

By CHARLES A. SCHOTT, Assistant.

COMPUTING DIVISION, COAST AND GEODETIC SURVEY.
*October* 24, 1885.

DEAR SIR: Accompanying this I submit a paper entitled "Magnetic dip and intensity, with their secular variation and geographical distribution in the United States," with three maps and three plates, intended to form Appendix No. 6, report for fiscal year 1884–'85.

This paper constitutes the concluding part of the magnetic researches lately undertaken by the Survey, those relating to the declination having been published in Appendices 12 and 13, report for 1882; the epoch of reduction being the same, viz, January, 1885.

Upon first taking up the subject, over thirty years ago, it became apparent that the time had not arrived for a profitable discussion of the very meager material then on hand. I have, therefore, confined my labors in the interval to the collection of observations, deferring discussion to a later time.

In the general table of magnetic dips and intensities now presented, there are, systematically arranged, 2000 dip observations and more than 1500 horizontal intensity observations. The order is by States and Territories, and for each division by latitude of station, and for each place the observations are given in chronological succession. This table, containing a general collection of all observed values (known to me) from the earliest times, will, it is supposed, be of more permanent value than the additional information it contains relating to the epoch 1885.

The discussion of the secular variation of the dip resulted in a more or less complete knowledge of the law of change during the last sixty years, and enabled me to recognize and delineate a belt of present "no change" with increasing dip on one side and decreasing dip on the other. A similar feature was recognized in the discussion of the secular variation of the horizontal intensity, the absolute measures of which hardly extend back half a century.

The above results are laid down on three diagrams, and the details of the present geographical distribution over the area of the United States are presented on three maps, on a scale adapted to the density of distribution of the observations and the intricacies of the isomagnetic curves.

Yours, respectfully,

CHAS. A. SCHOTT,
*Assistant.*

Mr. B. A. COLONNA,
*Assistant, in Charge Office and Topography.*

COLLECTION AND DISCUSSION OF RESULTS FOR DIP AND INTENSITY OF THE EARTH'S MAGNETIC FORCE WITHIN AND NEAR THE LIMITS OF THE UNITED STATES, WITH THEIR GEOGRAPHICAL DISTIBUTION AND SECULAR VARIATION AT THE EPOCH 1885.0, AS DEDUCED FROM OBSERVATIONS BETWEEN THE EARLIEST AND THE PRESENT TIME.

COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE.
*September* 11, 1885.

INTRODUCTION.

In the annual reports of the Coast and Geodetic Survey for the fiscal year 1880–'81 and the fiscal year 1881–'82 the subject of terrestrial magnetism, and in particular that part of it relating to the declination, has been brought to the latest practicable state of forwardness, as far as it relates to the operations of the Survey, and seems nearly exhaustive of the material so far accumulated by observers. It appeared, therefore, timely to direct attention to the state of our knowledge of the magnetic dip and intensity. Indeed, for years past it has seemed to me desirable to resume their discussion, which was abandoned nearly thirty years ago. During this time the demand for practical information about the magnetic dip and intensity has increased, mainly in consequence of the necessity of giving closer attention to the deviation and adjustment of the compass in iron and steel ships, though in this connection no high degree of accuracy of numerical values was required. The observations accumulated since 1855 gave a better prospect of obtaining clearer and more precise information respecting the law of the secular change of the dip and of the intensity, and, as will be seen in the sequel, this brief period embraced the (unsuspected) occurrence of a secondary maximum in the variation of the dip, as well as of a minimum in the variation of the horizontal component of the intensity.

But the principal object in view in making the present investigation was to advance our knowledge in this department of terrestrial physics by completing the work already undertaken by the Survey and bringing the results up to date. It was, therefore, indispensable first to prepare as complete a collection of data as could be brought together, to scrutinize and arrange them, and finally to discuss and present the results.

PART I.

In the general collection of data, as far as they were known or accessible to me, there are brought together in systematic form all observed dips and intensities within our boundaries from the earliest to the present time. The observations for dip and for horizontal and total intensities are arranged alphabetically, according to the present political divisions by States and Territories, and within each of these subdivisions the arrangement is by latitude, and for each station the several results, if any, are placed in strictly chronological order. To cover such adjacent regions outside of our boundaries as seemed desirable for the purpose of constructing isomagnetic charts, several geographical divisions are added to the collection. This arrangement then differs but in one particular from that adopted in 1882 in the case of the declinations, viz, it unites in one table *all* results, whereas the declinations, on account of their greater number, were more conveniently presented in *two* tables, the last containing the chronological arrangement for each place in connection with the discussion of the secular change.

No observations made at sea were admitted in the collection, these being in general less accurate, for want of complete elimination of the effect of local attraction on board ship. There are, however, a few results included obtained on the frozen ocean off the coast of Alaska, and it is only in this Territory that the question of the advisability of taking in observations made at sea could arise. Many such additional observations, if needed, might be taken from the Philosophical Transactions of the Royal Society for 1872, Contributions to Terrestrial Magnetism, No. XIII, by General Sir Edward Sabine.

The table provides for dips ($\theta$), horizontal intensities (H), and total intensities (F), but not for vertical intensities (V), as the latter are not subject to direct instrumental measure, whereas H, as well as F, may have been instrumentally determined, though where the results are given in absolute measure, H alone could have been directly so measured. In consequence of the mutual relations of $\theta$, H, V, F, when any two of these quantities are given by observation the other two may be found. The analytical dependence between the tabular values $\theta$, H, F may not always appear numerically strictly satisfied, for the reason that each of the three quantities results directly from independent observations, and thus necessarily is subject to error; hence the relation $H = F \cos \theta$ would be but partly satisfied, but when strictly satisfied by the tabular values it indicates that two only of the three values entering were derived from direct observation. Unless access can be had to the original records or discussion, it is not always possible to know which of these quantities were the original ones, though in refined work and in lower magnetic latitudes generally $\theta$ and H, and in the higher magnetic latitudes $\theta$ and F, will be found in the majority of cases to have been the fundamental, and F and H, respectively, the derived quantities; and there are even a few instances where $\theta$ is derived from relative measures of F and H. No attempt was made to fill in by computation the third quantity from the other two values, but the quantity was inserted when found already computed, and in some cases when specially needed. If the vertical component of the intensity is required, it may be computed from one of the following relations:

$$V = F \sin \theta = H \tan \theta = \sqrt{F^2 - H^2}$$

further we have also the simple relations:

$$F = H \sec \theta \qquad dF = \sec \theta \, d H + F \tan \theta \, d \theta \qquad \frac{dF}{F} = \frac{dH}{H} + \tan \theta \, d \theta$$

$$H = F \cos \theta \qquad dH = -F \sin \theta \, d \theta + \cos \theta \, d F \qquad \frac{dF}{F} = \cos^2 \theta \frac{dH}{H} + \sin^2 \theta \frac{dV}{V}$$

$$\frac{H}{F} = \cos \theta \qquad d \theta = -\frac{dH}{F \sin \theta} + \frac{\cot \theta}{F} d F \qquad \frac{dV}{V} = \operatorname{cosec}^2 \theta \frac{dF}{F} - \cot^2 \theta \frac{dH}{H}$$

$$dV = \operatorname{cosec} \theta \, d F - \cot \theta \, d H \qquad \frac{dV}{V} = \frac{d \theta}{\sin \theta \cos \theta} + \frac{dH}{H}$$

$$dV = H \sec^2 \theta \, d \theta + \tan \theta \, d H$$

All relative intensities were converted into absolute measures and expressed in terms of the English units—the foot, the grain, and the second of mean time; results expressed in Gaussian or French units, and in the British Association or centimetre-gramme-second (or C. G. S.) units, were all changed to conform to the majority of cases, in which the English units were employed.

On the maps which show the distribution of the horizontal and total intensities, referred to the epoch 1885.0, the centimetre-gramme-second (or C. G. S.) units are also introduced. (See figures within parentheses.)

### EXPLANATION OF THE GENERAL TABLE.

The general table of observed magnetic dips and intensities is subdivided and arranged by States, Territories, and adjacent foreign regions. Their number in each of these divisions is as follows:

| Number. | States and Territories. | Number of results. | | Number. | States and Territories. | Number of results. | |
|---|---|---|---|---|---|---|---|
| | | Dips. | Horizontal forces.* | | | Dips. | Horizontal forces.* |
| 1 | Alabama. | 9 | 9 | 9 | Delaware. | 9 | 8 |
| 2 | Alaska Territory. | 72 | 39 | 10 | District of Columbia. | 57 | 41 |
| 3 | Arizona Territory. | 69 | 34 | 11 | Florida. | 28 | 26 |
| 4 | Arkansas. | 0 | 0 | 12 | Georgia. | 21 | 22 |
| 5 | California. | 70 | 59 | 13 | Idaho Territory. | 7 | 8 |
| 6 | Colorado. | 9 | 9 | 14 | Illinois. | 33 | 16 |
| 7 | Connecticut. | 31 | 28 | 15 | Indiana. | 19 | 16 |
| 8 | Dakota Territory. | 4 | 4 | 16 | Indian Territory. | 3 | 3 |

* Directly or indirectly given.

| Number. | States and Territories. | Number of results. Dips. | Horizontal forces.* | Number. | States and Territories. | Number of results. Dips. | Horizontal forces.* |
|---|---|---|---|---|---|---|---|
| 17 | Iowa. | 28 | 25 | 40 | South Carolina. | 7 | 10 |
| 18 | Kansas. | 11 | 7 | 41 | Tennessee. | 19 | 18 |
| 19 | Kentucky. | 25 | 21 | 42 | Texas. | 18 | 11 |
| 20 | Louisiana. | 25 | 19 | 43 | Utah Territory. | 18 | 13 |
| 21 | Maine. | 76 | 51 | 44 | Vermont. | 13 | 11 |
| 22 | Maryland. | 40 | 35 | 45 | Virginia. | 37 | 36 |
| 23 | Massacusetts. | 76 | 55 | 46 | Washington Territory. | 37 | 39 |
| 24 | Michigan. | 65 | 49 | 47 | West Virginia. | 9 | 9 |
| 25 | Minnesota. | 13 | 13 | 48 | Wisconsin. | 24 | 19 |
| 26 | Mississippi. | 10 | 11 | 49 | Wyoming Territory. | 20 | 12 |
| 27 | Missouri. | 84 | 82 | | | | |
| 28 | Montana Territory. | 7 | 7 | 50 | Dominion of Canada, to longitude 75° W. | 55 | 40 |
| 29 | Nebraska. | 15 | 8 | | | | |
| 30 | Nevada. | 27 | 19 | 51 | Dominion of Canada, between longitudes 75° and 90° W. | 97 | 92 |
| 31 | New Hampshire. | 25 | 16 | | | | |
| 32 | New Jersey. | 36 | 32 | 52 | British Possessions, Northwestern America, south of latitude 51°. | 69 | 40 |
| 33 | New Mexico. | 18 | 5 | 53 | British Possessions, Northwestern America, north of latitude 51°. | 74 | 40 |
| 34 | New York. | 122 | 98 | | | | |
| 35 | North Carolina. | 18 | 16 | 54 | West India Islands and Bermudas. | 52 | 30 |
| 36 | Ohio. | 72 | 37 | 55 | Mexico and Central America. | 88 | 71 |
| 37 | Oregon. | 15 | 14 | 56 | Eastern Siberia. | 31 | 15 |
| 38 | Pennsylvania. | 70 | 66 | | Total number. | 1999 | 1523 |
| 39 | Rhode Island. | 12 | 9 | | | | |

* Directly or indirectly given.

The geographical divisions (50 to 56) comprise only such foreign parts contiguous to the United States which it appeared desirable to include for the study of the secular change of the magnetic elements or which would be useful in the construction of isomagnetic charts. Considerable labor was involved by the adoption of these divisions, since many of the States and Territories had no separate existence at the time when the earlier observations were recorded.

In each division the arrangement of the stations is by latitude, which offers advantages due to the circumstance that the isoclinic and isodynamic curves intersect the parallels of latitude generally at an acute angle.

The latitudes and longitudes as given in the original publications were scrutinized and corrected when possible, and in particular the telegraphic longitudes were introduced either directly or differentially; nevertheless there are many places whose positions are still imperfectly known for want of proper surveys. To avoid the large number of minus signs the longitude columns are headed "West longitude," except for the divisions Alaska and Eastern Siberia, where the west longitudes have been distinguished by a —, the east longitudes by a + sign, in conformity with the decision of the International Meridian Conference held at Washington in October, 1884.

A few dips, originally recorded in centesimal degrees, were changed to the usual division of the quadrant. For the change of relative into absolute measure of intensity the data will generally be found in the original publications, or else they were subsequently added and referred to in the last column of the table. Many of the intensities of the Canadian stations were expressed in relative measure, and it was a fortunate circumstance that Sir J. H. Lefroy's work, "Diary of a Magnetic Survey of a Portion of the Dominion of Canada, &c., in the years 1842-'44," London, 1883, appeared in time to be used in this paper. Dips and absolute intensities were transcribed from this volume unaltered in preference to any values formerly given. The results of the extensive series of observations of relative intensities by Dr. J. Locke, of Cincinnati, were taken from Art. XI of the Trans. of the Amer. Phil. Soc., 1846. "Observations made in the years 1838–'39–'40–'41–'42–'43 to determine the magnetic dip and the intensity of magnetic force in several parts of the United States, April, 1844." To these observations those of 1844 were afterwards added, which afforded additional means for the introduction of absolute values. The whole series was published by Sir E. Sabine in the Phil. Trans. Roy. Soc. for the year 1846, Part III. He finds from a series of comparisons at several stations that the total force in 1844 at Cincinnati, Dr. Locke's base station, was well represented by the number 1.795 of the arbitrary scale, in which Toronto was 1.836 in that year. At Toronto in 1844 the total force F was determined at 13.90 (hence with the observed dip we have also H=3.540), hence for Cincinnati F=13.59 . I have recomputed Dr. Locke's intensity observations after making a small allowance for secular diminution of H between the years 1838 and 1844, putting for Cincinnati $H_{1838}=4.560$ and $H_{1844}=4.548$, the latter value corresponding to the value of H given for that year for Toronto.

For the conversion of the relative measures (in Phil. Trans. Roy. Soc., 1838) by Captain Sir Everard Home in the West Indies and other localities during 1834–'35–'36–'37, I have used for his initial station, Plymouth, England, the values $\theta_{1835}=69^\circ\ 20'$, $H_{1835}=3.639$ and $F_{1835}=10.31$ .

For the conversion into absolute measure of D. Douglas' series on the Western coast between 1830 and 1833, I have used for his base stations Fort Vancouver, $H_{1830}=4.442$; Monterey, $H_{1831}=5.629$; and London, $F_{1833}=10.388$ .

The relative total intensities by Captain Whipple and Lieutenant Ives in 1850–'53–'54 are given in absolute measure by means of the base station, Cambridge, Mass., $F_{1853}=13.37$ .

In those cases where Washington was used as a base station, the annual values of H and F will be found in Part III of this paper in connection with the secular variation of the intensity, and it may also be remarked that at this station we have a direct comparison of instrumental constants as determined at Kew, England, and at Washington through the observations made here by Dr. Thorpe, who visited the United States in 1878 on the occasion of the solar eclipse of that year. The tabular results as observed and computed show a satisfactory accord.

Some further information respecting the change from relative to absolute intensities for the earlier series of observations will be found in Coast Survey Report for 1861, Appendix No. 22, and we have only to remark that all such results prior to the time, 1833–1836, when Gauss showed how to express the magnetic force in absolute measure and Weber constructed his portable magnetometer, are necessarily of inferior accuracy, and in part conjectural, and it should also be remembered that in early times observers like Humboldt, Franklin, Sabine, and others, down to 1823, measured differentially the earth's magnetic force by counting the oscillations of the dipping-needle—a method long since abandoned on account of its inferiority. Lloyd's statical method, especially when it combines gravity and magnetic deflections, is capable of excellent results, as shown, for instance, by Lieutenant Ackley's observations in the West Indies in 1879–'80, when that method was employed in connection with oscillations of the horizontal needle for the purpose of direct comparisons.

The tabular results in general take no cognizance of the diurnal and annual variations of the dip and the intensity, these corrections being too small in comparison with the observing errors.

For explanation of the tabular values of $\theta$, H, and F, as referred to the adopted epoch 1885.0, see Parts II and III of this paper.

TABLE I.—*Observed magnetic dips and horizontal and total*

ALABAMA.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Fort Morgan, Mobile Point. | 30 13.9 | 88 01.2 | 1847 | May 19, 20, 29. | ---- | 6.218 |
| Mobile, Batre's garden. | 30 41.4 | 88 01.5 | {1834 / 1835} | May. | 61 38 | 6.115 |
| Mobile. | 30 41.6 | 88 02.6 | 1857 | Feb. 9–25. | 60 51.0 | 6.150 |
| Lower Peach Tree. | 31 50.4 | 87 32.7 | 1857 | Apr. 3; May 2, 4, 5. | 62 16.8 | 5.975 |
| Eufaula. | 31 53.7 | 85 08.4 | 1860 | Apr. 10–14. | 63 05.8 | 5.739 |
| Montgomery, Capitol Square. | 32 22.8 | 86 18.0 | 1856 | Apr. 2, 3, 4, 5, 7, 8 | 63 05.4 | 5.859 |
| Tuscaloosa. | 33 12 | 87 42 | 1835 | April. | 64 22 | ---- |
| Indian Mountain. | 34 01.8 | 85 25.6 | 1875 | Aug. 23, 24, 25. | 65 09.5 | 5.472 |
| Decatur. | 34 37 | 86 59 | 1881 | Aug. 26, 27, 29. | 65 35.2 | 5.312 |
| Florence. | 34 47 | 87 43 | 1881 | Sept. 5, 6. | 65 52.1 | 5.297 |

ALASKA TERRITORY.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Kyska Harbor, Kyska Island. | 51 59.1 | *+177 30.0 | 1873 | July 22. | 65 01.3 | ---- |
| Chichagoff Harbor, Attu Island. | 52 56.0 | +173 12.4 | 1873 | June 26. | 65 10.6 | ---- |
| Unalashka, Cove Point, Chernoffsky Bay. | 53 24.0 | −167 29.9 | 1880 | Oct. 2. | 67 13.8 | 4.544 |
| Unalashka Island, Captain's Harbor. | 53 55 | −166 30 | 1778 | Oct. 12. | 69 23.5 | ---- |
| Unalashka. | 53 52.4 | −166 31.9 | 1817 | June. | 68 45 | ---- |
| Unalashka, Captain's Harbor. | 53 54 | −166 30 | 1827 | Aug. 11. | 68 25.6 | ---- |
| Do. | 53 54 | −166 30 | 1829 | ---- | 68 26 | ---- |
| Unalashka, Iliuliuk. | 53 52 | −166 30 | 1849 | ---- | 68 22 | ---- |
| Unalashka, Iliuliuk Harbor. | 53 52.9 | −166 31.7 | 1880 | July, Oct. | 67 35.8 | 4.456 |
| Do. | 53 52.9 | −166 31.7 | 1883 | Sept. 19, 20, 21. | ---- | 4.386 |
| Howcan Mission, Kaigani Straits. | 54 49.5 | −132 50 | 1881 | Sept. 1, 2. | 74 21.5 | 3.805 |
| Northwest Harbor, Little Koniushi, Shumagin Islands. | 55 03.3 | −159 23.5 | 1880 | July 16. | 69 30.3 | 4.198 |
| Tamgas Harbor, Gravina Islands. | 55 04 | −131 28 | 1883 | July 27, 28; Aug. 8. | 74 28.2 | 3.478 |
| Belkoffsky Settlement, Dolgoi Island. | 55 05.2 | −162 00.2 | 1880 | July 23. | 69 16.2 | 4.193 |
| Humboldt Harbor, Popoff Island, Shumagins. | 55 19.3 | −160 31.0 | 1880 | July 19. | 69 28.8 | 4.208 |
| Ward's Cove, Tongass Narrows. | 55 22.7 | −131 43.6 | 1882 | Oct. 4. | 74 36.2 | 3.375 |
| Kasaan Bay, Prince of Wales Archipelago. | 55 29.5 | −132 19.0 | 1880 | May 9. | 73 58 | ---- |
| Shakan, Prince of Wales Islands. | 56 09.4 | −133 38.5 | 1881 | Aug 15, 16. | 74 49.7 | 3.395 |
| Fort Wrangell, Etolin Harbor. | 56 28.2 | −132 22.5 | 1880 | May 10. | 75 19.2 | ---- |
| Do. | 56 28.2 | −132 22.5 | 1881 | Aug. 17–21. | 75 32.8 | 3.265 |
| Hot Springs Bay, Sitka Sound. | 56 51.7 | −135 20.3 | 1880 | June 9. | 75 01.9 | 3.345 |
| Sitka, a few leagues off shore. | 56 54 | −135 25 | 1786 | Aug. 6, 7. | 73 30 (?) | ---- |
| Portage Bay, Prince Frederick Sound. | 57 00.2 | −133 20.0 | 1882 | Oct. 31, Nov. 1. | 75 08.3 | 3.290 |

* West longitudes have negative signs; east longitudes have positive signs.

*magnetic intensities in the United States and adjacent regions.*

ALABAMA.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| ---- | ° ---- | ---- | ---- | R. H. Fauntleroy and J. S. Ruth. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | } 61.1 | 6.15 | 12.73 { | J. N. Nicollet. | C. S. Rpt., 1864, App. 19. Obs'd mean $\theta$=63° 28'; prob. index cor'n = −1° 50'. H mean of obs'ns in May, 1834, and May, 1835, epoch 1834.9 . |
| 12.625 | | | | E. Goodfellow. | C. & G. S. Rpt., 1881, App. 9. |
| 12.846 | 62.1 | 5.98 | 12.78 | G. W. Dean. | Do. |
| 12.684 | 62.9 | 5.74 | 12.60 | Do. | Do. |
| 12.946 | 62.9 | 5.86 | 12.87 | Do. | Do. |
| ---- | 64.2 | ---- | ---- | J. N. Nicollet. | C. S. Rpt., 1864. Dip corrected by − 1° 50' for probable index cor'n. |
| 13.025 | 65.01 | 5.47 | 12.95 | F. P. Webber. | C. & G. S. Rpt., 1881, App. 9. |
| 12.852 | 65.53 | 5.312 | 12.83 | J. B. Baylor. | Do. |
| 12.956 | 65.81 | 5.297 | 12.93 | Do. | Do. |

ALASKA TERRITORY.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| ---- | 64.7 | ---- | ---- | W. H. Dall. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 64.9 | ---- | ---- | Do. | Do. |
| 11.74 | 67.1 | 4.54 | 11.67 | W. H. Dall and M. Baker. | Do. |
| ---- | | | | J. Cook. | Encyc. Met. London, 1848. Art. Magnetism. |
| ---- | | | | O. v. Kotzebue. | F. P. Lütke. Voyage, &c., party nautique. |
| 12.15 | | | | F. P. Lütke. | F. P. Lütke. Voyage, &c., party nautique. Rpt. Brit. Asso., vol. VI, 1838. |
| 12.47 | } 67.5 | 4.41 | 11.52 { | Do. | Phil. Trans. R. S., 1872. Sir E. Sabine. |
| ---- | | | | Tebenkoff. | Tebenkoff's Atlas. |
| 11.69 | | | | W. H. Dall and M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | R. A. Marr. | MS. in C. & G. S. Office. |
| 14.11 | 74.3 | 3.80 | 14.04 | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| 11.99 | 69.4 | 4.18 | 11.88 | W. H. Dall and M. Baker. | Do. |
| 12.990 | 74.4 | 3.47 | 12.90 | H. E. Nichols. | MS. in C. & G. S. Office. |
| 11.84 | 69.2 | 4.18 | 11.77 | W. H. Dall and M. Baker. | C. &. G. S. Rpt., 1881, App. 9. |
| 12.00 | 69.4 | 4.19 | 11.91 | Do. | Do. |
| 12.710 | 74.5 | 3.37 | 12.61 | H. E. Nichols. | MS. in C. & G. S. Office. |
| ---- | 73.9 | ---- | ---- | W. H. Dall and M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| 12.97 | 74.7 | 3.39 | 12.85 | H. E. Nichols. | Do. |
| ---- | } 75.4 | 3.26 | 12.93 { | W. H. Dall & M. Baker. | Do. |
| 13.08 | | | | H. E Nichols. | Do. |
| 12.95 | } 74.9 | 3.34 | 12.82 { | W. H. Dall & M. Baker. | Do. |
| ---- | | | | J. F. G. de La Perouse. | Voyage, &c. Paris, 1797, vol. 3. $\theta$ apparently too small. |
| 12.828 | 75.1 | 3.29 | 12.79 | H. E. Nichols. | MS. in C. & G. S. Office. |

**TABLE I.—*Observed magnetic dips and horizontal and total magnetic***

ALASKA TERRITORY—Continued.

| Name of station. | Latitude φ. | *Longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Sitka, near. | 57 02.8 | —135 06.6 | 1818 | July. | 76 33 | ---- |
| Sitka. | 57 03 | —135 20 | 1827 | ---- | 75 55 | ---- |
| Do. | 57 03 | —135 20 | 1829.9 | ---- | 75 50.6 | ---- |
| Do. | 57 03 | —135 22 | 1837 | ---- | 75 51.5 | ---- |
| Do. | 57 03 | —135 22 | 1839 | ---- | 75 49.1 | 3.207 |
| Sitka, Japonski Island Observatory. | 57 03 | —135 20 | 1842 | ---- | 75 51 | ---- |
| Do. | 57 03 | —135 20 | 1845 | Jan. to Dec. | 75 54.6 | ---- |
| Sitka. | 57 03 | —135 20 | 1851 | ---- | 76 20 | ---- |
| Sitka, Japonski Island, near old Russian Magnetic Observatory. | 57 02.9 | —135 20.3 | 1880 | May 17, 18. | 75 11.7 | 3.310 |
| Do. | 57 02.9 | —135 20.3 | 1881 | Sept. 12–16. | 75 16.6 | 3.293 |
| Saint Paul Island, Pribiloff Islands. | 57 07.3 | —170 19.0 | 1880 | Aug. 6. | 68 36.6 | 4.356 |
| Kadiak, near Cape Greville. | 57 20 | —152 51 | 1839 | July. | 72 42.9 | 3.635 |
| Povorotny Station, Peril Strait. | 57 28.4 | —135 27.5 | 1880 | May 20. | 75 03.4 | ---- |
| Marble Bluff, Chatham Strait. | 57 45 | —134 43.5 | 1880 | May 22. | 75 57.3 | ---- |
| Saint Paul, Kadiak Island. | 57 48.0 | —152 21.3 | 1880 | July 12. | 72 34.6 | 3.721 |
| New Point Marsden, Admiralty Island. | 58 05 | —134 49 | 1880 | May 23. | 76 02.1 | 3.124 |
| Cross Sound, Granite Cove, Port Althorp. | 58 12 | —136 24 | 1794 | July. | 78 58.5 | ---- |
| Port Althorp, Cross Sound. | 58 11.5 | —136 23.5 | 1880 | June 19. | 75 22.3 | 3.279 |
| Point Whidbey, Lynn Canal. | 58 36.5 | —135 15 | 1880 | May 24. | 76 27.3 | ---- |
| Lituya Bay (Port Français). | 58 39 | —137 30 | 1786 | ---- | 73 52 (?) | ---- |
| Seduction Island, Lynn Canal. | 58 59.5 | —135 22 | 1880 | May 29. | 76 44.3 | ---- |
| Pyramid Island Harbor, Lynn Canal. | 59 10.6 | —135 28.5 | 1880 | May 25, 26. | 75 34.7 | 3.277 |
| Kohklux. | 59 23.7 | —135 53.5 | 1869 | July 31, Aug. 2, 3. | 75 44 | 3.297 |
| Port Mulgrave. | 59 33.7 | —139 46.3 | 1791 | July 1. | 76 46.8 | ---- |
| Do. | 59 33.7 | —139 45.9 | 1880 | June 24. | 76 17.9 | 3.067 |
| Coal Point, Cook's Inlet. | 59 36.1 | —151 23.6 | 1880 | June 30. | 73 59.6 | 3.464 |
| Chalmer's Haven. | 60 16 | —147 25 | 1794 | ---- | 77 08.5 | ---- |
| Port Etches. | 60 21 | —146 41 | 1837 | ---- | 76 02.9 | 3.150 |
| Saint Michael's, Norton Sound. | 63 29.8 | —162 05.7 | 1879 | ---- | 75 06 | ---- |
| Norton Bay. | 64 31 | —162 47 | 1778 | ---- | 76 25 | ---- |
| Port Clarence and Grantley Bay. | 65 17 | —166 19 | 1850 | ---- | 75 48 | ---- |
| Do. | 65 17 | —166 19 | 1854 | ---- | { 77 26 (?) / 76 30 } | ---- |
| Port Clarence. | 65 17 | —166 30 | 1879 | July. | 76 05 | 3.028 |
| Do. | 65 16.1 | —166 50.6 | 1880 | Sept. 6, 8. | 76 04.0 | 3.022 |

* West longitudes have negative signs; east longitudes have positive signs.

*intensities in the United States and adjacent regions.—Continued.*

ALASKA TERRITORY—Continued.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| ---- | | | | V. M. Golovnin. | Voyage around the world. St. Petersburg, 1822, vol. II. |
| 13. 14 | | | | F. P. Lütke. | Rpt. Brit. Asso., vol. VI, London, 1838, & Phil. Trans. R. S., 1872. Sabine's value, F = 12.98. |
| 13. 07 | | | | A. Erman. | Rpt. Brit. Asso., vol. VI, London, 1838, & Phil. Trans. R. S., 1872. Sabine's value, F = 12.90. |
| ---- | | | | E. Belcher. | Phil. Trans. R. S., 1843, pt. 2. & 1872. Sabine's value for 1837 & 1839, F = 12. 77. |
| 13. 10 | 75. 15 | 3. 30 | 12. 88 | Do. | Do. |
| ---- | | | | Observatory. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883, p. xxi. |
| ---- | | | | Do. | M. Baker from Annuaire Met. & Mag., St. Petersburg. |
| ---- | | | | Collinson. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883, p. xxi. |
| 12. 95 | | | | W. H. Dall & M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| 12. 96 | | | | H. E. Nichols. | Do. |
| 11. 94 | 68. 5 | 4. 35 | 11. 87 | W. H. Dall & M. Baker. | Do. |
| 12. 11 | ---- | ---- | ---- | E. Belcher. | Phil. Trans. R. S., 1843 & 1872. |
| ---- | 74. 9 | ---- | ---- | W. H. Dall & M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 75. 8 | ---- | ---- | Do. | Do. |
| 12. 43 | 72. 5 | 3. 72 | 12. 37 | Do. | Do. |
| 12. 94 | 75. 9 | 3. 12 | 12. 81 | Do. | Do. |
| ---- | 75. 2 | 3. 28 | 12. 84 | G. Vancouver. | Encyc. Met., London, 1848, Art. Magnetism, & Vancouver's Voyage, Vol. III. |
| 12. 98 | | | | W. H. Dall & M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 76. 3 | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | J. F. G. de La Perouse. | Encyc. Met., London, 1848, Art. Magnetism. |
| ---- | 76. 6 | ---- | ---- | W. H. Dall & M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| 13. 15 | 75. 5 | 3. 28 | 13. 10 | Do. | Do. |
| 13. 38 | 75. 3 | 3. 29 | 12. 97 | G. Davidson. | Do. |
| ---- | 76. 2 | 3. 06 | 12. 83 | Don A. Malaspina. | Bode's Astr. Jahrb., Berlin, 1828. |
| 12. 95 | | | | W. H. Dall & M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| 12. 56 | 73. 9 | 3. 46 | 12. 48 | Do. | Do. |
| ---- | ---- | ---- | ---- | G. Vancouver. | Encyc. Met., London, 1848, Art. Magnetism. |
| 12. 94 | ---- | ---- | ---- | E. Belcher. | Phil. Trans. R. S., 1843 & 1872. |
| ---- | 75. 0 | ---- | ---- | U. S. Revenue Marine. | Pacific Coast Pilot, U. S. C. & G. S., 1883. |
| ---- | ---- | ---- | ---- | J. Cook. | Encyc. Met., London, 1848, Art. Magnetism, & Vancouver's Voyage, Vol. III. |
| ---- | | | | Collinson. | Phil. Trans. R. S., 1872. |
| ---- | | | | Do. | Do. |
| | 76. 0 | 3. 025 | 12. 50 | R. Maguire. | |
| 12. 59 | | | | A. Wÿkander. | Nordenskiold in the Vega. |
| 12. 55 | | | | W. H. Dall and M. Baker. | C. & G. S. Rpt., 1881, App. 9. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

ALASKA TERRITORY—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Kotzebue Sound, Chamisso Island. | 66 13 | —161 49 | 1827 | ---- | 77 39 | ---- |
| Chamisso Harbor, Kotzebue Sound. | 66 13.3 | —161 48.7 | 1880 | Aug. 31. | 77 17.4 | 2.791 |
| Fort Yukon. | 66 33.8 | —145 17.8 | 1869 | Aug. 14, 16, 26. | 79 49.5 | 2.478 (?) |
| Near Cape Lisburne. | 68 52.9 | —166 05.5 | 1880 | Aug. 21. | 78 53.0 | 2.460 |
| On ice, near Nuwnak. | 70 09 | —143 50 | 1851 | ---- | 82 58 | ---- |
| Sandy Beach, between Port Lay and Icy Cape. | 70 13.2 | —162 15.2 | 1880 | Aug. 25. | 80 07.8 | 2.195 |
| Foggy Island. | 70 16 | —147 38 | 1825 | ---- | 82 26 | ---- |
| Near Point Belcher. | 70 47 | —159 40 | 1880 | Aug. 27. | 80 52.6 | 2.025 |
| Ooglaamie, Point Barrow. | 71 17.7 | —156 39.7 | 1881 | Dec. | 81 24.6 | 1.932 |
| Do. | 71 17.7 | —156 39.7 | 1882 | Jan. to Dec. | 81 23.5 | 1.935 |
| Do. | 71 17.7 | —156 39.7 | 1883 | Jan. to July and Aug. | 81 23.1 | 1.937 |
| Plover Point, Point Barrow. | 71 21.4 | —156 16.1 | 1854 | ---- | 81 36 | ---- |
| Point Barrow, near extreme point. | 71 22.5 | —156 20 | 1881 | Summer. | 81 18 | ---- |
| On ice, north and east of Point Barrow. | 71 26 | —147 26 | 1851 | ---- | 83 05 | ---- |
| On ice. | 71 27 | —155 14 | 1851 | ---- | 82 29 | ---- |

ARIZONA TERRITORY.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Santa Cruz River. | 31 18 | 110 31 | 1855 | May 14. | 57 28 | 6.169 |
| San Bernardino. | 31 20 | 109 14 | 1855 | Apr. 28. | 57 19 | 6.252 |
| Los Nogales. | 31 21 | 110 51 | 1855 | June 16. | 57 13 | 6.262 |
| Station 45. | 32 41 | 114 05 | 1851 | ---- | 58 25 | ---- |
| Gila Junction. | 32 43 | 114 33 | 1851 | ---- | 58 30 | ---- |
| Station 44. | 32 44 | 113 50 | 1851 | ---- | 58 30 | ---- |
| Station 43. | 32 49 | 113 33 | 1851 | ---- | 58 43 | ---- |
| Station 1. | 32 50 | 109 34 | 1851 | ---- | 59 19 | ---- |
| Station 2. | 32 50 | 109 37 | 1851 | ---- | 59 12 | ---- |
| Station 3. | 32 53 | 109 44 | 1851 | ---- | 59 12 | ---- |
| Station 4. | 32 57 | 109 49 | 1851 | ---- | 59 20 | ---- |
| Station 42. | 32 58 | 113 11 | 1851 | ---- | 59 17 | ---- |
| Station 20. | 32 59 | 110 40 | 1851 | ---- | 59 11 | ---- |
| Station 39. | 32 59 | 112 43 | 1851 | ---- | 58 49 | ---- |
| Station 38. | 33 00 | 112 39 | 1851 | ---- | 58 53 | ---- |
| Station 28. | 33 01 | 111 23 | 1851 | ---- | 59 16 | ---- |
| Station 40. | 33 02 | 112 55 | 1851 | ---- | 59 16 | ---- |
| Station 21. | 33 03 | 110 46 | 1851 | ---- | 58 59 | ---- |
| Station 27. | 33 03 | 111 16 | 1851 | ---- | 59 20 | ---- |
| Station 5. | 33 04 | 109 55 | 1851 | ---- | 59 27 | ---- |
| Station 26. | 33 04 | 111 11 | 1851 | ---- | 59 25 | ---- |
| Station 29. | 33 04 | 111 34 | 1851 | ---- | 59 06 | ---- |

*intensities in the United States and adjacent regiosn.—Continued.*

ALASKA TERRITORY—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| ---- | 77.2 | 2.79 | 12.59 | Beechey. | Beechey's Voyage to the Pacific, London, 1831. |
| 12.68 | | | | W. H. Dall and M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| 14.02(?) | 79.5 | ---- | ---- | C. W. Raymond. | Senate Ex. Doc. No. 12, Wash., 1871. H doubtful: first set of deflections alone used. |
| 12.76 | 78.8 | 2.46 | 12.66 | W. H. Dall and M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | ---- | ---- | ---- | Collinson. | Phil. Trans. R. S., 1872. |
| 12.81 | 80.0 | 2.20 | 12.67 | W. H. Dall and M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | ---- | ---- | ---- | J. Franklin. | Phil. Trans. R. S., 1872. |
| 12.84 | 80.8 | 2.03 | 12.70 | W. H. Dall and M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| 12.935 | 81.34 | 1.950 | 12.95 | P. H. Ray. | C. & G. S. Rpt., 1883, App. 13. |
| 12.929 | | | | Do. | Do. |
| 12.927 | | | | Do. | Do. |
| ---- | ---- | ---- | ---- | R. Maguire. | Phil. Trans. R. S., 1872. |
| ---- | 81.23 | ---- | ---- | U. S. Revenue Marine. | Pacific Coast Pilot, Alaska, U. S C. & G. S., 1883. |
| ---- | ---- | ---- | ---- | Collinson. | Phil. Trans. R. S., 1872. |
| ---- | ---- | ---- | ---- | Do. | Do. |

ARIZONA TERRITORY.

| | | | | | |
|---|---|---|---|---|---|
| 11.47 | ---- | 6.04 | ---- | W. H. Emory. | U. S. & Mex. Bound. Sur.; Am. Acad. of Sc., Vol. VI, 1856. |
| 11.58 | ---- | 6.13 | ---- | Do. | Do. |
| 11.56 | ---- | 6.14 | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | W. H. Emory and T. W. Chandler. | U. S. & Mex. Bound. Sur.; Am. Acad. of Sc., Vols. V & VI, 1856. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

ARIZONA TERRITORY—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Station 19. | 33 05 | 110 35 | 1851 | ---- | 59 05 | ---- |
| Station 22. | 33 05 | 110 50 | 1851 | ---- | 59 13 | ---- |
| Station 6. | 33 06 | 110 00 | 1851 | ---- | 59 38 | ---- |
| Station 24. | 33 06 | 111 02 | 1851 | ---- | 59 20 | ---- |
| Station 23. | 33 07 | 110 55 | 1851 | ---- | 59 23 | ---- |
| Station 30. | 33 08 | 111 44 | 1851 | ---- | 59 06 | ---- |
| Station 12. | 33 09 | 110 26 | 1851 | ---- | 59 37 | ---- |
| Station 13. | 33 09 | 110 28 | 1851 | ---- | 58 58 | ---- |
| Station 15. | 33 09 | 110 31 | 1851 | ---- | 59 28 | ---- |
| Station 32. | 33 09 | 111 57 | 1851 | ---- | 59 22 | ---- |
| Station 7. | 33 10 | 110 03 | 1851 | ---- | 59 42 | ---- |
| Station 31. | 33 10 | 111 54 | 1851 | ---- | 59 28 | ---- |
| Station 8. | 33 12 | 110 10 | 1851 | ---- | 59 37 | ---- |
| Station 10. | 33 12 | 110 19 | 1851 | ---- | 59 34 | ---- |
| Station 17. | 33 12 | 110 42 | 1851 | ---- | 59 23 | ---- |
| Station 9. | 33 13 | 110 19 | 1851 | ---- | 59 45 | ---- |
| Williams River. | 34 13 | 113 33 | 1854 | Feb. 15. | 60 08 | ---- |
| Camp 123. | 34 14 | 113 39 | 1854 | Feb. 16. | 60 10 | ---- |
| Williams River. | 34 17 | 113 26 | 1854 | Feb. 13. | 60 14 | ---- |
| Camp 126. | 34 17 | 113 56 | 1854 | Feb. 20. | 60 11 | ---- |
| On Colorado River. | 34 23 | 114 06 | 1854 | Feb. 21. | 60 34 | ---- |
| Camp 129. | 34 27 | 114 11 | 1854 | Feb. 22. | 60 35 | ---- |
| Williams River. | 34 32 | 113 28 | 1854 | Feb. 9. | 60 44 | ---- |
| Do. | 34 36 | 113 28 | 1854 | Feb. 8. | 60 36 | ---- |
| Camp 130. | 34 36 | 114 16 | 1854 | Feb. 23. | 60 30 | ---- |
| Camp 132. | 34 46 | 114 23 | 1854 | Feb. 25 | 60 48 | ---- |
| Camp 135. | 34 52 | 114 32 | 1854 | Mar. 1. | 60 57 | ---- |
| Colorado Chiquito or Flax River. | 34 53 | 110 04 | 1853 | Dec. 5. | 62 15 | ---- |
| Pueblo Creek. | 34 56 | 112 46 | 1854 | Jan. 21. | 61 13 | ---- |
| Near Rio Puerco of the West. | 34 58 | 109 52 | 1853 | Dec. 3. | 61 46 | ---- |
| Williams River. | 34 59 | 112 57 | 1854 | Jan. 23. | 61 06 | ---- |
| On Colorado Chiquito. | 35 00 | 110 25 | 1853 | Dec. 7. | 61 54 | ---- |
| Do. | 35 01 | 110 30 | 1853 | Dec. 8. | 61 41 | ---- |
| Big Horse Spring. | 35 01 | 113 36 | 1854 | Feb. 4. | 61 02 | ---- |
| Near Lithodendron Creek. | 35 02 | 109 41 | 1853 | Dec. 2. | 61 57 | ---- |
| Jacob's Well. | 35 04 | 109 14 | 1853 | Nov. 29. | 61 59 | ---- |
| On Colorado Chiquito. | 35 05 | 110 33 | 1853 | Dec. 15. | 61 44 | ---- |
| Navajo Springs. | 35 06 | 109 20 | 1853 | Nov. 30. | 61 58 | ---- |
| Carriso Creek. | 35 06 | 109 32 | 1853 | Dec. 1. | 62 05 | ---- |
| Williams River. | 35 07 | 113 13 | 1854 | Jan. 28. | 61 17 | ---- |
| White Cliff Creek. | 35 08 | 113 31 | 1854 | Feb. 1. | 60 48 | ---- |
| On Colorado Chiquito. | 35 12 | 110 37 | 1853 | Dec. 16. | 61 45 | ---- |

*intensities in the United States and adjacent regions.—Continued.*

ARIZONA TERRITORY—Continued.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| ---- | ---- | ---- | ---- | W. H. Emory and T. W. Chandler. | U. S. & Mex. Bound. Sur.; Am. Acad. of Sc., Vols. V & VI, 1856. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| 12.11 | ---- | 5.90 | ---- | J. C. Ives and A. W. Whipple. | C. S. Rpt., 1856, p. 222. |
| 12.07 | ---- | 5.88 | ---- | Do. | Do. |
| 12.13 | ---- | 5.89 | ---- | Do. | Do. |
| 12.06 | ---- | 5.87 | ---- | Do. | Do. |
| 12.09 | ---- | 5.81 | ---- | Do. | Do. |
| 12.10 | ---- | 5.81 | ---- | Do. | Do. |
| 12.10 | ---- | 5.79 | ---- | Do. | Do. |
| 12.06 | ---- | 5.79 | ---- | Do. | Do. |
| 12.10 | ---- | 5.83 | ---- | Do. | Do. |
| 12.11 | ---- | 5.78 | ---- | Do. | Do. |
| 12.16 | ---- | 5.77 | ---- | Do. | Do. |
| 12.42 | ---- | 5.65 | ---- | Do. | Do. |
| 12.28 | ---- | 5.78 | ---- | Do. | Do. |
| 12.41 | ---- | 5.74 | ---- | Do. | Do. |
| 12.25 | ---- | 5.79 | ---- | Do. | Do. |
| 12.39 | ---- | 5.71 | ---- | Do. | Do. |
| 12.37 | ---- | 5.74 | ---- | Do. | Do. |
| 12.13 | ---- | 5.74 | ---- | Do. | Do. |
| 12.40 | ---- | 5.70 | ---- | Do. | Do. |
| 12.46 | ---- | 5.72 | ---- | Do. | Do. |
| 12.36 | ---- | 5.72 | ---- | Do. | Do. |
| 12.47 | ---- | 5.73 | ---- | Do. | Do. |
| 12.45 | ---- | 5.70 | ---- | Do. | Do. |
| 12.03 | ---- | 5.65 | ---- | Do. | Do. |
| 12.25 | ---- | 5.85 | ---- | Do. | Do. |
| 12.41 | ---- | 5.74 | ---- | Do. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

ARIZONA TERRITORY—Continued.

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Head of White Cliff Creek. | 35 12 | 113 21 | 1854 | Jan. 30. | 61 14 | ---- |
| Saroux Spring. | 35 17 | 111 39 | 1853 | Dec. 29. | 61 33 | ---- |
| On Colorado Chiquito. | 35 18 | 110 53 | 1853 | Dec. 17. | 61 55 | ---- |
| Do. | 35 21 | 110 56 | 1853 | Dec. 18. | 62 03 | ---- |
| Cedar Creek. | 35 21 | 112 20 | 1854 | Jan. 9. | 62 06 | ---- |

ARKANSAS.

[No magnetic dip or intensity stations in the State.]

CALIFORNIA.

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| San Diego. | 32 42 | 117 14 | 1793 | Nov. and Dec. | 59 13 | ---- |
| San Diego, tongue on eastern side. | 32 41 | 117 13 | 1839 | ---- | 57 06.1 | 6.142 |
| San Diego. | 32 42 | 117 10 | 1849 | ---- | 57 33 | ---- |
| San Diego, La Playa. | 32 42.2 | 117 14.5 | 1853 | Sept. and Oct. | 57 38.6 | 6.271 |
| San Diego Bay. | 32 42 | 117 13 | 1866 | June 15. | 57 54 | 6.261 |
| San Diego, La Playa. | 32 42.2 | 117 14.6 | 1872 | Nov. 22, 23. | 57 56.8 | 6.159 |
| Do. | 32 42.2 | 117 14.5 | 1881 | Apr. 5, 6. | 57 51.2 | 6.104 |
| New River. | 32 42 | 115 25 | 1849 | ---- | 58 19 | ---- |
| Santa Maria. | 33 02 | 116 51 | 1849 | ---- | 58 42 | ---- |
| Santa Isabella. | 33 08 | 116 41 | 1849 | ---- | 58 48 | ---- |
| San Pedro, on a small island 3 miles north of San Pedro. | 33 43 | 118 15 | 1839 | ---- | 58 21.4 | 5.913 |
| San Pedro. | 33 45.4 | 118 17.0 | 1853 | Nov. and Dec. | 59 32.6 | 6.144 |
| Do. | 33 44.2 | 118 16.7 | 1881 | Apr. 10, 11. | 58 48.5 | 5.991 |
| Dominguez Hill. | 33 51.8 | 118 14.2 | 1870 | Mar. 17, 18. | 58 49.2 | 6.056 |
| Santa Monica. | 34 00.5 | 118 29.7 | 1883 | Apr. 10. | 59 02.8 | 5.973 |
| Los Angeles, Coast and Geodetic Survey Observatory. | 34 03.0 | 118 15.4 | 1882 | Sept., Oct., Nov., Dec. | 59 30.4 | 5.9126 |
| Do. | 34 03.0 | 118 15.4 | 1883 | Monthly. | 59 30.7 | 5.9191 |
| Do. | 34 03.0 | 118 15.4 | 1884 | Monthly. | 59 29.4 | 5.9151 |
| Do. | 34 03.0 | 118 15.4 | 1885 | Jan'y to July. | 59 29.8 | 5.9111 |
| San Buenaventura. | 34 15.8 | 119 15.9 | 1870 | Jan. 13–19. | 59 11.5 | 6.018 |
| Santa Barbara. | 34 24 | 119 42 | 1831 | May. | 60 48 | 5.861 |
| Santa Barbara, at landing place. | 34 24 | 119 42 | 1839 | ---- | 58 54.1 | 5.925 |
| Santa Barbara, N. NW. of Geodetic station on outermost spur of hill. | 34 24.2 | 119 42.8 | 1869 | Nov. 20–25. | 59 16.0 | 5.967 |
| Santa Barbara, west of long wharf near Burton House. | 34 24.6 | 119 41.5 | 1881 | Apr. 13, 14. | 59 19.2 | 5.871 |

*intensities in the United States and adjacent regions.—Continued.*

ARIZONA TERRITORY—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| 12.34 | ---- | 5.81 | ---- | J. C. Ives and A. W. Whipple. | C. S. Rpt. 1856, p. 222. |
| 12.34 | ---- | 5.75 | ---- | Do. | Do. |
| 12.40 | ---- | 5.71 | ---- | Do. | Do. |
| 12.48 | ---- | 5.72 | ---- | Do. | Do. |
| 12.46 | ---- | 5.70 | ---- | Do. | Do. |

ARKANSAS.

[No magnetic dip or intensity stations in the State.]

CALIFORNIA.

| | | | | | |
|---|---|---|---|---|---|
| ---- | | | | G. Vancouver. | Hansteen's Erdmagnetismus, Christiania, 1819. |
| 11.32 | | | | E. Belcher. | Phil. Trans. R. S., 1841 and 1843, and C. S. Rpt. 1861, App. 22. |
| ---- | | | | W. H. Emory. | U. S. and Mex. Bound. Sur.; Am. Acad. Sc., Vol. VI, 1856. |
| 11.72 | 57.88 | 6.087 | 11.45 | W. P. Trowbridge. | C. & G. S. Rpt., 1881, App. 9. |
| 11.782 | | | | W. Harkness. | Smithsonian Cont's to Know., No. 239, Wash., 1873. Prof. W. Harkness, U. S. N. |
| 11.60 | | | | S. R. Throckmorton. | C. & G. S. Rpt., 1881, App. 9. |
| 11.47 | | | | H. E. Nichols. | Do. |
| ---- | 58.3 | ---- | ---- | W. H. Emory. | U. S. & Mex. Bound. Sur.; Am. Acad. Sci., Vol. VI, 1856. |
| ---- | 58.7 | ---- | ---- | Do. | Do. |
| ---- | 58.8 | ---- | ---- | Do. | Do. |
| 11.28 | | | | E. Belcher. | Phil. Trans. R. S., 1841; C. S. Rpt., 1861, App. 22. |
| 12.12 | 58.8 | 5.968 | 11.52 | W. P. Trowbridge. | C. & G. S. Rpt., 1881, App. 9. |
| 11.57 | | | | H. E. Nichols. | Do. |
| 11.70 | 58.8 | 5.970 | 11.52 | G. Davidson and S. R. Throckmorton. | Do. |
| 11.613 | 59.1 | 5.965 | 11.62 | M. Baker. | M. S. in C. & G. S. Office. |
| 11.652 | | | | M. Baker. | Do. |
| 11.666 | 59.50 | 5.911 | 11.65 | Do. | Do. |
| 11.651 | | | | M. Baker and C. Terry. | Do. |
| 11.646 | | | | C. Terry. | Do. |
| 11.75 | 59.2 | 5.932 | 11.58 | G. Davidson and S. R. Throckmorton. | C. & G. S. Rpt., 1881, App. 9. |
| 12.02 | | | | D. Douglas. | Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1875; Sir E. Sabine's Cont., XIV, and C. S. Rpt., 1861, App. 22. |
| 11.48 | 59.29 | 5.860 | 11.47 | E. Belcher. | Phil. Trans. R. S., 1841 and 1843; C. S. Rpt., 1861, App. 22. |
| 11.68 | | | | G. Davidson and S. R. Throckmorton. | C. & G. S. Rpt., 1881, App. 9. |
| 14.51 | | | | H. E. Nichols. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

CALIFORNIA—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Point Conception, El Coxo. | 34 27.0 | 120 26.7 | 1872 | Dec. 9, 10, 11. | 58 51.0 | 5.905 |
| Santa Inez. | 34 36 | 120 11 | 1831 | May. | 60 53 | 5.818 |
| La Purissima. | 34 40 | 120 27 | 1831 | May. | 60 53 | 5.788 |
| Soda Lake. | 35 03 | 115 59 | 1854 | Mar. 8. | 61 07 | ---- |
| Pai-ute Creek. | 35 06 | 114 54 | 1854 | Mar. 3. | 61 10 | ---- |
| Sand Camp. | 35 06 | 115 46 | 1854 | Mar. 7. | 60 49 | ---- |
| San Luis Obispo. | 35 11 | 120 44 | 1831 | May. | 61 17 | 5.754 |
| Do. | 35 10.6 | 120 44.5 | 1854 | Jan. and Feb. | 59 42.2 | 6.002 |
| Do. | 35 10.6 | 120 44.5 | 1881 | Apr. 16, 17. | 60 30.0 | 5.831 |
| Near Marl Spring. | 35 11 | 115 33 | 1854 | Mar. 6. | 60 56 | ---- |
| San Miguel. | 35 45 | 121 00 | 1831 | Apr. | 61 40 | 5.686 |
| San Antonio. | 36 01 | 121 18 | 1831 | Apr. | 61 46 | 5,674 |
| La Soledad. | 36 24 | 121 24 | 1831 | Apr. | 62 04 | 5.661 |
| Mount Toro. | 36 31.5 | 121 36.5 | 1885 | Jan. 27 to Feb. 2. | ---- | 5.663 |
| Monterey. | 36 36 | 121 51 | 1791 | Sept. 23. | 60 56.2 | ---- |
| Do. | 36 36 | 121 51 | 1792 | Dec. | 63 00.5 | ---- |
| Do. | 36 36 | 121 51 | 1794 | Nov. | 63 00 | ---- |
| Monterey, at the presidio. | 36 36 | 121 53 | 1818 | Sept. | 64 15 | ---- |
| Monterey, near landing place. | 36 35 | 121 55 | 1831 | Jan. | 62 07.5 | 5.629 |
| Do. | 36 36 | 121 53 | 1839 | ---- | 61 03.6 | 5.666 |
| Monterey. | 36 36 | 121 53 | 1843 | Sept. | 61 58.9 | ---- |
| Monterey, at the barracks of redoubt. | 36 36.2 | 121 53.8 | 1854 | May 19–25. | 60 59.5 | 5.802 |
| Near Monterey, Point Pinos. | 36 37.8 | 121 55.6 | 1873 | Sept. 1, 2. | 61 12.5 | 5.696 |
| Monterey, at the barracks, officers' quarters. | 36 36.2 | 121 53.8 | 1881 | Apr. 19, 20. | 61 12.7 | 5.663 |
| Mt. Bache, or Loma Prieta. | 37 06.6 | 121 50.6 | 1884 | Mar. 15, 16, 17. | ---- | 5.591 |
| Sierra Morena. | 37 24.5 | 122 18.5 | 1884 | Jan. 15, 16, 17. | ---- | 5.541 |
| San José. | 37 32 | 122 00 | 1831 | July. | 62 52 | 5.550 |
| San Francisco Bay. | 37 48.5 | 122 22 | 1815 | Nov. 1. | 62 46 | ---- |
| San Francisco. | 37 48 | 122 24 | 1829 | ---- | ---- | ---- |
| Do. | 37 48 | 122 24 | 1831 | Feb. | 62 58.0? | 5.495 |
| Do. | 47 48 | 122 24 | 1837 | ---- | 61 53.8 | ---- |
| San Francisco, Yerba Buena Island. | 37 48 | 122 24 | 1839 | ---- | 62 05.8 | 5.524 |
| San Francisco, presidio. | 37 47.5 | 122 27.2 | 1852 | Feb. 11, 12. | 62 21.2 | ---- |
| San Francisco, Dupont street, near Catholic church, and near Stockton and California sts. | 37 47.8 | 122 24.0 | 1858 | June 5, 6, 7, 10, 13 | 62 47 | { 5.591<br>5.561 |
| San Francisco. | 37 49 | 122 21 | 1866 | June 26. | 62 22 | 5.643 |

*intensities in the United States and adjacent regions*—*Continued.*

CALIFORNIA—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 11.41 | ° 58.9 | 5.836 | 11.30 | S. R. Throckmorton. | C. & G. S. Rpt., 1881, App. 9. |
| 11.96 | ---- | 5.818 | ---- | D. Douglas. | Rpt. Brit. Asso., Vol. VI. 1838, and Phil. Trans. R. S., 1841 and 1875. |
| 11.89 | ---- | 5.788 | ---- | Do. | Do. |
| 12.15 | ---- | 5.763 | ---- | J. C. Ives and A. W. Whipple. | C. S. Rpt., 1856, p. 222. |
| 12.16 | ---- | 5.758 | ---- | Do. | Do. |
| 12.14 | ---- | 5.814 | ---- | Do. | Do. |
| 11.96 | | | | D. Douglas. | Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1841 and 1875; C. S. Rpt., 1861, App. 22. |
| 11.90 | 60.50 | 5.821 | 11.82 | W. P. Trowbridge. | C. & G. S. Rpt., 1881, App. 9. |
| 11.84 | | | | H. E. Nichols. | Do. |
| 12.10 | ---- | 5.773 | ---- | J. C. Ives and A. W. Whipple. | C. S. Rpt., 1856, p. 222. |
| 11.96 | ---- | 5.686 | --- | D. Douglas. | Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1841 and 1875. |
| 11.99 | ---- | 5.674 | ---- | Do. | Do. |
| 12.04 | ---- | 5.661 | ---- | Do. | Do. |
| ---- | ---- | 5.663 | ---- | G. Davidson and F. Morse. | MS. in C. & G. S. Office. |
| ---- | | | | Don A. Malaspina. | Bode's Astr. Jahrb., Berlin, 1828. |
| ---- | | | | G. Vancouver. | Hansteen's Erdmagnetismus, Christiania, 1819. |
| ---- | | | | Do. | Do. |
| ---- | | | | V. M. Golovnin. | Voyage round the World, St. Petersburg, 1822, Vol. 2. |
| 12.07 | 61.21 | 5.647 | 11.73 | D. Douglas. | Rpt. Brit. Asso., Vol. VI, 1838; C. S. Rpt., 1861, App. 22. |
| 11.71 | | | | E. Belcher. | Phil. Trans. R. S., 1843. |
| ---- | | | | T. Perry. | Sill. J., Vol. XLVII. |
| 11.96 | | | | W. P. Trowbridge. | C. & G. S. Rpt., 1881, App. 9. |
| 11.83 | | | | S. R. Throckmorton. | Do. |
| 11.76 | | | | H. E. Nichols. | Do. |
| ---- | ---- | 5.588 | ---- | G. Davidson and R. A. Marr. | MS. in C. & G. S. Office. |
| ---- | ---- | 5.536 | ---- | Do. | Do. |
| 12.17 | ---- | 5.550 | ---- | D. Douglas. | Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1841 and 1875. |
| ---- | | | | Kotzebue. | Voyage of Discovery, 1815–1818. |
| 12.00 | | | | Erman. | Phil. Trans. R. S., 1846. |
| 12.09 | | | | D. Douglas. | Rpt. Brit. Asso., Vol. VI., 1838; C. S. Rpt., 1861, App. 22. *Gauss gives 62° 38′ in his comparison of theory and observation.* |
| ---- | | | | E. Belcher. | Phil. Trans. R. S., 1841. |
| 11.81 | 62.33 | 5.495 | 11.83 | Do. | Phil. Trans. R. S., 1841 and 1843; C. S. Rpt., 1861, App. 22. |
| ---- | | | | G. Davidson and F. A. Roe | C. & G. S. Rpt., 1881, App. 9. |
| 12.19 / 12.10 | | | | K. Friesach. | Acad. Sc., Vienna, Vol. 38, 1860. |
| 12.167 | | | | W. Harkness. | Smithsonian Cont's to Know., No. 239, Wash., 1873, Cruise of the Monadnock. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

CALIFORNIA—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| San Francisco, Presidio. | 37 47.5 | 122 27.2 | 1873 | Nov. 13–20. | 62 05.1 | 5.543 |
| Do. | 37 47.5 | 122 27.2 | 1880 | Apr. and Nov. | 62 18.8 | 5.526 |
| Do. | 37 47.5 | 122 27.2 | 1880 | Sept. 24–26. | 62 19.0 | 5.501 |
| Do. | 37 47.5 | 122 27.2 | 1881 | Mar. 30; Apr. 1. | 62 17.6 | 5.537 |
| Do. | 37 47.5 | 122 27.2 | 1881 | Apr. to Nov. | 62 30.0 | 5.488 |
| San Francisco, Lafayette Park. | 37 47.4 | 122 25.6 | 1881 | Feb. and June. | 62 17.8 | 5.537 |
| San Francisco, Presidio. | 37 47.5 | 122 27.2 | 1881 | June, July, Dec. | 62 25.2 | 5.530 |
| Do. | 37 47.5 | 122 27.2 | 1883 | June 2, 3, 4, 5. | ---- | 5.481 |
| Do. | 37 47.5 | 122 27.2 | 1884 | Sept. 5–24. | 62 20.2 | 5.485 |
| Mount Diablo. | 37 52.8 | 121 54.8 | 1884 | Nov. 29, 30; Dec. 2, 3, 5. | ---- | 5.542 |
| San Francisco, Solano. | 38 17 | 122 24 | 1831 | July. | 63 24 | 5.467 |
| Port Bodega. | 38 18 | 123 02 | 1839 | ---- | 62 53.4 | 5.440 |
| Bodega Head, Fort Rumantsoff. | 38 18.7 | 122 43.2 | 1818 | Sept. | 65 30 | ---- |
| Bodega, near geodetic station. | 38 18.2 | 123 00.1 | 1860 | Aug. 15–17. | ---- | 5.558 |
| Vaca. | 38 22.4 | 122 05.0 | 1880 | Nov. 23–29. | ---- | 5.476 |
| Sacramento. | 38 35 | 121 27 | 1852 | ---- | 64 03 | ---- |
| Sacramento, grounds of the Capitol. | 38 36.1 | 121 28.0 | 1881 | Apr. 5, 6, 7. | 63 40.7 | 5.368 |
| Monticello. | 38 39.7 | 122 11.4 | 1880 | Oct. 6–16. | 63 14.2 | 5.419 |
| Blue Cañon. | 39 15.3 | 120 47.0 | 1881 | Apr. 9–10. | 64 22.3 | 5.260 |

COLORADO.

| | | | | | | |
|---|---|---|---|---|---|---|
| La Junta, near eclipse station. | 37 58.9 | 103 32.6 | 1878 | July 25. | 66 02.3 | 5.2761 |
| Pueblo. | 38 12 | 104 37 | 1872 | Oct. 15, 16. | 66 38.3 | 5.124 |
| North Pueblo, south of Court-House. | 38 18 | 104 36.8 | 1878 | Aug. 19–23. | 66 31.3 | 5.183 |
| Colorado Springs. | 38 50.0 | 104 49.1 | 1873 | Aug. 30; Sept. 3. | 66 51.4 | 5.041 |
| Manitou, near the Navajo Soda Spring. | 38 51.9 | 104 54.6 | 1878 | Aug. 4. | 66 59.2 | 5.0649 |
| Denver, on Pierce's Block. | 39 45 | 105 00 | 1872 | Oct. 13, 14, 19. | 67 34.4 | 4.945 |
| Denver, at astronomical station. | 39 45.4 | 104 59.5 | 1873 | Aug. 13, 14, 15. | 67 27.2 | 4.985 |
| Denver, near Seventeenth street and Broadway. | 39 45.3 | 104 59.5 | 1878 | Sept. 3–6. | 67 30.7 | 4.968 |
| Denver, Mrs. Craig's garden. | 39 45.3 | 104 59.6 | 1878 | Aug. 8. | 67 32.8 | 4.9847 |

CONNECTICUT.

| | | | | | | |
|---|---|---|---|---|---|---|
| Stamford. | 41 03.5 | 73 32.3 | 1844 | Sept. 12, 13. | 73 02.3 | 3.885 |
| Norwalk. | 41 07.1 | 73 24.6 | 1844 | Sept. 14. | 73 09.8 | ---- |
| Bridgeport. | 41 10 | 73 11 | 1845 | Sept. 17. | 73 21.3 | 3.738 |

*intensities in the United States and adjacent regions.—Continued.*

CALIFORNIA—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 11.84 | ° 62.33 | 5.495 | 11.83 | G. Davidson, S. R. Throckmorton, and W. Eimbeck. | C. & G. S. Rpt., 1881, App. 9. |
| 11.89 | | | | W. H. Dall and M. Baker. | Do. |
| 11.84 | | | | H. E. Nichols. | Do. |
| 11.91 | | | | W. Eimbeck and R. A. Marr. | Do. |
| 11.89 | | | | H. E. Nichols. | Do. |
| 11.91 | | | | J. S. Lawson. | Do. |
| 11.94 | | | | Do. | Do. |
| ---- | | | | R. A. Marr. | MS. in C. & G. S. Office. |
| 11.82 | | | | G. Davidson and R. A. Marr. | Do. |
| ---- | ---- | 5.542 | ---- | G. Davidson and R. A. Marr. | Do. |
| 12.22 | ---- | 5.467 | ---- | D. Douglas. | Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1841 & 1875. |
| 11.94 | ---- | 5.435 | ---- | E. Belcher. | Phil. Trans. R. S., 1841 & 1843. |
| ---- | ---- | 5.443 | ---- | V. M. Golovnin. | Voyage 'round the World, St. Petersburg, 1822, Vol. 2. |
| ---- | | | | G. Davidson. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | ---- | 5.454 | ---- | E. F. Dickins. | Do. |
| ---- | 63.65 | 5.350 | 12.05 | W. H. Emory. | U. S. & Mex. Bound. Sur.; Am. Acad. Sc., Vol. VI, 1856. |
| 12.11 | | | | W. Eimbeck and R. A. Marr. | C. & G. S. Rpt., 1881, App. 9. |
| 12.03 | 63.25 | 5.397 | 11.99 | G. Davidson and J. J. Gilbert. | Do. |
| 12.16 | 64.35 | 5.242 | 12.11 | W. Eimbeck and R. A. Marr. | Do. |

COLORADO.

| | | | | | |
|---|---|---|---|---|---|
| 12.991 | 66.0 | 5.28 | 12.98 | T. E. Thorpe. | Proc. R. S., No. 200, 1880. |
| ---- | 66.5 | 5.15 | 12.91 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, (Nat. Acad. Ser.) |
| 13.01 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 12.83 | 66.9 | 5.05 | 12.87 | E. Smith. | Do. |
| 12.956 | | | | T. E. Thorpe. | Proc. R. S., No. 200, 1880. |
| ---- | 67.5 | 4.97 | 12.99 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, (Nat. Acad. Ser.) |
| 13.00 | | | | E. Smith. | C. & G. S. Rpt., 1881, App. 9. |
| 12.99 | | | | J. B. Baylor. | Do. |
| 13.051 | | | | T. E. Thorpe. | Proc. R. S., No. 200, 1880. |

CONNECTICUT.

| | | | | | |
|---|---|---|---|---|---|
| 13.32 | 72.17 | 3.944 | 12.88 | J. Renwick. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 72.29 | ---- | ---- | Do. | Do. |
| 13.05 | 72.48 | 3.805 | 12.64 | Do. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

CONNECTICUT—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Double Beach. | 41 14.5 | 72 51 | 1884 | July 22. | 72 50.4 | ---- |
| Light-House point. | 41 15 | 72 54 | 1884 | June 30. | 72 46.1 | ---- |
| Tashua. | 41 15.6 | 73 15.0 | 1863 | Aug. 31; Sept. 17 | 73 00.8 | 3.887 |
| Saybrook. | 41 16.5 | 72 20.6 | 1845 | Aug. 19. | 74 33.8 | 3.564 |
| New Haven, burial ground. | 41 18 | 72 56 | 1839 | Sept. | 73 26.7 | 3.832 |
| New Haven. | 41 18 | 72 57 | 1842 | Apr. 21. | 73 29.8 | 3.819 |
| New Haven, Grove Street, near cemetery. | 41 18 | 72 57 | 1842 | Oct. 18. | 73 27.4 | 3.831 |
| New Haven, Yale College and station southeast of it. | 41 18.5 | 72 55.7 | 1844 | Aug. 27–29. | {73 21.0<br>27.5 | } 3.818 |
| New Haven, Fort Wooster. | 41 16.9 | 72 53.6 | 1847 | Sept. 27–Oct. 2. | 74 16.6 | 3.667 |
| New Haven, at the Pavilion. | 41 18.0 | 72 54.6 | 1848 | Aug. 14–18. | 73 31.9 | 3.776 |
| New Haven, Fort Wooster. | 41 16.9 | 72 53.6 | 1848 | Aug. 21–26. | 74 12.6 | 3.617 |
| New Haven, Oyster Point. | 41 17.0 | 72 55.7 | 1848 | Aug. 30, 31. | 73 32.9 | 3.769 |
| Do | 41 16.9 | 72 55.8 | 1855 | Aug. 17. | 73 44.5 | 3.690 |
| New Haven, Silliman's Garden. | 41 18.7 | 72 55.6 | 1878 | July 17, 18. | 73 05.4 | 3.861 |
| New Haven, Yale College Observatory. | 41 18.7 | 72 55.6 | 1884 | Jan. to Dec. | 72 49.6 | 3.8704 |
| Do. | 41 18.7 | 72 55.6 | 1885 | Apr. 22. | 72 47.6 | 3.860 |
| New London. | 41 18.4 | 72 00.3 | 1845 | Aug. 13. | 72 57.9 | ---- |
| Stonington. | 41 19.8 | 71 54.3 | 1845 | Aug. 8, 9. | 73 25.1 | 3.748 |
| Wooster. | 41 21.0 | 73 29.3 | 1864 | July 20; Aug. 6. | 73 24.6 | 3.818 |
| Centreville. | 41 23.0 | 72 54.2 | 1884 | June, Aug. | 72 49.9 | ---- |
| Sandford. | 41 27.7 | 72 57.0 | 1862 | Sept. 30; Oct. 10. | 73 33.3 | 3.855 |
| Hartford, northwest of State-House. | 41 46 | 72 41 | 1839 | Sept. | 73 58.1 | ---- |
| Hartford, in park. | 41 45.9 | 72 40.5 | 1859 | July 27. | 74 07.4 | 3.716 |
| Hartford, yard of Perkins' house, Prospect street. | 41 45.9 | 72 40.4 | 1867 | Aug. 15, 17. | 73 20.5 | 3.801 |
| Hartford, in park. | 41 45.9 | 72 40.5 | 1879 | July 24, 25. | 73 25.7 | 3.783 |
| Box Hill. | 41 47.9 | 72 27.3 | 1861 | Oct. 21–25. | 73 57.9 | 3.743 |
| Ivy. | 41 52.3 | 73 13.5 | 1863 | June 23; July 17. | 73 32.0 | 3.792 |
| Bald Hill. | 41 58.3 | 72 11.9 | 1861 | Sept. 10–20. | 73 47.5 | 3.715 |

DAKOTA TERRITORY.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Yankton. | 42 54 | 97 28 | 1880 | Oct. 9, 11. | 72 52.2 | 4.124 |
| Bismarck | 46 46.3 | 100 38 | 1880 | Sept. 21, 22. | 74 55.7 | 3.617 |
| Jamestown. | 46 53.2 | 98 45 | 1880 | Sept. 15, 16. | 75 35.7 | 3.457 |
| Pembina | 48 59 | 97 14 | 1880 | Sept. 9, 10. | 77 27.9 | 3.033 |

*intensities in the United States and adjacent regions.—Continued.*

CONNECTICUT—Continued.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | · | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| 13.178 | 72.75 | 3.897 | 13.14 | O. T. Sherman. | Rpt. to Board of Managers of Yale Coll. Observatory, 1884–'85. |
| 13.159 | | | | Do. | Do. |
| 13.30 | 72.03 | 3.987 | 12.92 | S. H. Lyman, G. W. Dean, and A. D. Bache. | C. & G. S. Rpt., 1881, App. 9. |
| 13.39 | 73.69 | 3.631 | 12.93 | J. Renwick. | Do. |
| 13.35 | | | | E. Loomis. | Sill. J., 1840; Am. Phil. Soc., Vol. VIII, 1843; C. S. Rpt., 1861, App. 22. |
| 13.45 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844. |
| 13.453 | | | | J. H. Lefroy. | Diary Mag. Sur., Canada, London, 1883. |
| 13.33 | | | | J. Renwick. | C. & G. S. Rpt., 1881, App. 9. |
| 13.53 | 72.73 | 3.865 | 13.02 | R. H. Fauntleroy. | Do. |
| 13.32 | | | | J. S. Ruth. | Do. |
| 13.29 | | | | Do. | Do. |
| 13.31 | | | | Do. | Do. |
| 13.18 | | | | C. A. Schott. | Do. |
| 13.274 | | | | T. E. Thorpe. | Proc. R. S., No. 200, 1880. |
| ---- | | | | O. T. Sherman. | Rpt. to Board of Managers of Yale Coll. Observatory, 1883–'84. |
| ---- | | | | Do. | Rpt. to Board of Managers of Yale Coll. Observatory, 1884–'85. |
| ---- | 72.09 | ---- | ---- | J. Renwick. | C. & G. S. Rpt., 1881, App. 9. |
| 13.13 | 72.54 | 3.814 | 12.71 | Do. | Do. |
| 13.37 | 72.43 | 3.913 | 12.96 | R. E. Halter and A. D. Bache. | Do. |
| 13.129 | 72.78 | 3.878 | 13.10 | O. T. Sherman. | Rpt. Board of Managers of Yale Coll. Observatory, 1884–'85. |
| 13.62 | 72.58 | 3.960 | 13.23 | E. Goodfellow and A. D. Bache. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | E. Loomis. | Sill. J., Vol. XXXIX, 1840. |
| 13.58 | | | | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.26 | 72.76 | 3.840 | 12.96 | Do. | Do. |
| 13.26 | | | | J. B. Baylor. | Do. |
| 13.55 | 72.96 | 3.854 | 13.15 | G. W. Dean, R. E. Halter, and A. D. Bache. | Do. |
| 13.38 | 72.55 | 3.892 | 12.98 | S. H. Lyman, G. W. Dean, and A. D. Bache. | Do. |
| 13.31 | 72.79 | 3.826 | 12.93 | G. W. Dean, R. E. Halter, and A. D. Bache. | Do. |

DAKOTA TERRITORY.

| | | | | | |
|---|---|---|---|---|---|
| 14.00 | 72.85 | 4.13 | 14.01 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.91 | 74.91 | 3.62 | 13.91 | Do. | Do. |
| 13.90 | 75.58 | 3.46 | 13.90 | Do. | Do. |
| 13.97 | 77.44 | 3.03 | 13.93 | Do. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

DELAWARE.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Dagsborough. | 38 35.0 | 75 15.6 | 1856 | Aug. 28. | 71 03.1 | 4.348 |
| Pilot-town. | 38 47.1 | 75 09.5 | 1846 | July 2. | 71 18.5 | 4.290 |
| Cape Henlopen Light-House. | 38 46.5 | 75 05.3 | 1856 | Aug. 27. | 71 22.0 | 4.285 |
| Bombay Hook. | 39 21.8 | 75 30.7 | 1846 | June 17. | 71 39.5 | 4.201 |
| Delaware City. | 39 35 | 75 36 | 1842 | ---- | 71 46 | ---- |
| Fort Delaware. | 39 35.3 | 75 34.2 | 1846 | June 14, 15. | 71 34.9 | 4.226 |
| Sawyer. | 39 42.1 | 75 34.0 | 1846 | June 3. | 71 57.5 | 4.175 |
| Wilmington. | 39 44.9 | 75 33.9 | 1846 | May 28. | 71 25.4? | 4.236 |
| Do. | 39 46.6 | 75 32.5 | 1875 | July 17, 22; Oct. 4. | 71 24.0 | 4.364 |

DISTRICT OF COLUMBIA.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Washington. | 38 53.5 | 77 01 | 1838 | ---- | 71 13 | ---- |
| Washington, park fronting Capitol. | 38 53.5 | 77 00.5 | 1839 | Feb. | 71 17.5 | ---- |
| Washington, front of the Capitol. | 38 53.5 | 77 00.5 | 1839 | Sept. | 71 21.4 | ---- |
| Washington, north of Capitol. | 38 53.6 | 77 00.6 | {1840, 1841} | ---- | 71 20.2 | ---- |
| Washington, east of the Capitol. | 38 53.5 | 77 00.5 | 1841 | June and Aug. | 71 15.2 | ---- |
| Do. | 38 53.5 | 77 00.5 | 1841 | July. | 71 14.4 | ---- |
| Washington, Capitol Hill. | 38 53.4 | 77 00.5 | 1841 | Sept. | 71 15.9 | ---- |
| Washington, north of Capitol. | 38 53.6 | 77 00.6 | {1841, 1842} | ---- | 71 18.0 | ---- |
| Washington, park east of Capitol. | 38 53.4 | 77 00.5 | 1842. | ---- | 71 13.1 | ---- |
| Washington, grounds west of Capitol. | 38 53.4 | 77 00.8 | 1842 | Oct. 10. | 71 13.8 | 4.316 |
| Washington, near War Department. | 38 53.9 | 77 02.4 | 1843 | Jan. | ---- | 4.320 |
| Washington, Gilliss' Magnetic Observatory, north of Capitol. | 38 53.6 | 77 00.6 | 1844 | Apr. 6. | 71 39.3 | 4.277 |
| Washington, old depot near Georgetown. | 38 53.7 | 77 03 | 1844 | Apr. 8. | 71 34.8 | 4.274 |
| Washington, west and east sides Capitol grounds. | 38 53.4 | 77 00.7 | 1844 | Apr. 9. | 71 13.4 | 4.309 |
| Washington, near Patent Office. | 38 53.9 | 77 01.4 | 1844 | Apr. 10. | 71 15.0 | 4.289 |
| Washington, near War Department. | 38 53.9 | 77 02.4 | 1844 | Apr. 11. | 71 20.5 | 4.307 |
| Washington, near Capitol, east side. | 38 53.5 | 77 00.5 | 1844 | July. | 71 10.6 | ---- |
| Washington, near old Coast Survey Office, south of Capitol. | 38 53.1 | 77 00.6 | 1845 | Jan. to May and Nov. | 71 33.9 | {4.240, 4.233} |
| Washington, northwest of the Capitol. | 38 53.6 | 77 01.0 | 1852 | May, June. | 71 16.1 | 4.267 |
| Washington, near White House and Navy Department. | 38 53.5 | 77 02 | 1853 | May 28. | 71 21.4 | ---- |
| Washington, grounds of Smithsonian Institution | 38 53.2 | 77 01.6 | 1855 | July, Sept. | 71 27.0 | 4.337 |
| Washington, grounds east of Capitol. | 38 53.3 | 77 00.5 | 1856 | Aug. 15. | 71 19.6 | 4.308 |
| Washington, near old Coast Survey Office, south of Capitol. | 38 53.1 | 77 00.6 | 1856 | Aug., Sept. | 71 21.7 | 4.308 |
| Do. | 38 53.1 | 77 00.6 | 1857 | Mar. | 71 22.5 | ---- |

***intensities in the United States and adjacent regions.—Continued.***

DELAWARE.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| 13.39 | 70.45 | 4.434 | 13.25 | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.39 | 70.80 | 4.355 | 13.24 | J. Locke. | Do. |
| 13.41 | 70.77 | 4.371 | 13.27 | C. A. Schott. | Do. |
| 13.35 | 71.15 | 4.266 | 13.20 | J. Locke. | Do. |
| ---- | 71.25 | ---- | ---- | Barnett. | Phil. Trans. R. S., 1875. |
| 13.38 | 71.07 | 4.291 | 13.23 | J. Locke. | C. & G. S. Rpt., 1881, App. 9. |
| 13.48 | 71.45 | 4.240 | 13.33 | Do. | Do. |
| ---- | 70.96 | 4.352 | 13.34 | Do. | C. & G. S. Rpt., 1881, App. 9. Also $\theta=72° 24'.5$; local disturbance at this place. |
| 13.68 | | | | J. M. Poole. | C. & G. S. Rpt., 1881, App. 9. Local disturbance at this place. |

DISTRICT OF COLUMBIA.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| ---- | | | | C. Wilkes. | Sill. J., Vol. XXXIX, 1840. |
| ---- | | | | C. Wilkes and E. Loomis. | Sill. J., Vol. XLIII, 1842. |
| ---- | | | | E. Loomis. | Sill. J., Vol. XXXIX, 1840. |
| ---- | | | | J. M. Gilliss. | Sill. J., Vol. I, 1846. |
| ---- | | | | J. N. Nicollet. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | | | | J. D. Graham and J. N. Nicollet. | Do. |
| ---- | | | | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| ---- | | | | J. M. Gilliss. | Sill. J., Vol. I, 1846. |
| ---- | | | | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| 13.414 | | | | J. H. Lefroy. | Diary Mag. Sur. Canada, London, 1883. |
| ---- | | | | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.59 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.53 | | | | Do. | Do. |
| 13.39 | | | | Do. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. Same results for W. & E. sides. |
| 13.35 | | | | Do. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.47 | | | | Do. | Do. |
| ---- | | | | J. D. Graham. | Am. Phil. Soc., Vol. VII, 1844. |
| 13.41<br>13.39 | | | | T. J. Lee. | C. & G. S. Rpt., 1881, App. 9. |
| 13.29 | | | | J. E. Hilgard. | Do. |
| ---- | | | | J. M. Gilliss. | U. S. Ast. Expedition to Chili, Vol. VI. |
| 13.63 | | | | C. A. Schott. | C. & G. S. Rpt.. 1881, App. 9. Locality affected by local disturbance. |
| 13.45 | | | | Do. | C. & G. S. Rpt., 1881, App. 9. |
| 13.48 | | | | Do. | Do. |
| ---- | | | | W. Reed. | C. S. Rpt., 1858, App. 26. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

DISTRICT OF COLUMBIA—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Washington, near old Coast Survey Office, south of Capitol. | 38 53.1 | 77 00.6 | 1858 | June 2. | 71 22.6 | 4.255 |
| Do. | 38 53.1 | 77 00.6 | 1859 | June and July. | 71 24.4 | 4.307 |
| Do. | 38 53.1 | 77 00.6 | 1860 | Aug. and Sept. | 71 15.9 | 4.319 |
| Do. | 38 53.1 | 77 00.6 | 1861 | ---- | 71 18.3 | ---- |
| Do. | 38 53.1 | 77 00.6 | 1862 | July, Aug., Sept. | 71 18.5 | 4.284 |
| Do. | 38 53.1 | 77 00.6 | 1863 | July 18–28. | 71 14.3 | 4.294 |
| Do. | 38 53.1 | 77 00.6 | 1865 | June 27. | 71 11.7 | ---- |
| Washington, grounds United States Naval Observatory. | 38 53.7 | 77 03.1 | 1866 | Nov. 1. | 72 02 (?) | 4.300 |
| Do. | 38 53.7 | 77 03.1 | 1867 | May 6. | 71 58 | ---- |
| Washington, near old Coast Survey Office, south of Capitol. | 38 53.1 | 77 00.6 | 1867 | May 6. | 71 26 | ---- |
| Washington, magnetic observatory, Schott's garden, corner Second and C streets southeast. | 38 53.1 | 77 00.2 | 1867 | Jan. to Dec. | 71 06.7 | 4.321 |
| Do. | 38 53.1 | 77 00.2 | 1868 | Jan. to Dec. | 71 03.4 | 4.334 |
| Do. | 38 53.1 | 77 00.2 | 1869 | May 15. | 71 19.2 | ---- |
| Do. | 38 53.1 | 77 00.2 | 1869 | Jan. to July. | 70 57.9 | 4.347 |
| Do. | 38 53.1 | 77 00.2 | 1870 | June 13, 14, 15. | 70 55.3 | 4.352 |
| Do. | 38 53.1 | 77 00.2 | 1871 | June 14, 15, 16. | 70 59.9 | 4.356 |
| Do. | 38 53.1 | 77 00.2 | 1872 | June 14, 15, 17. | 71 00.6 | 4.360 |
| Do. | 38 53.1 | 77 00.2 | 1873 | June 14, 16, 17. | 70 58.5 | 4.344 |
| Do. | 38 53.1 | 77 00.2 | 1874 | June 13, 15, 16. | 70 52.4 | 4.349 |
| Do. | 38 53.1 | 77 00.2 | 1875 | June 12, 14, 15. | 70 51.0 | 4.353 |
| Do. | 38 53.1 | 77 00.2 | 1876 | May 1, 2. | 70 47.3 | 4.357<br>4.356 |
| Washington magnetic observatory, Schott's garden, near corner First and B streets southeast. | 38 53.2 | 77 00.4 | 1877 | June 14, 15, 16.<br>Aug. and Dec. | 70 49.1 | 4.366<br>4.373 |
| Do. | 38 53.2 | 77 00.4 | 1878 | June, Sept., Dec. | 70 49.3<br>70 46.9 | 4.368<br>4.361<br>4.374 |
| Do | 38 53.2 | 77 00.4 | 1879 | June 9, 10, 11. | 70 48.4 | 4.370 |
| Do. | 38 53.2 | 77 00.4 | 1880 | June 12–17.<br>July 9, 10, 12. | 70 46.4<br>70 43.4 | 4.378<br>4.372 |
| Do. | 38 53.2 | 77 00.4 | 1881 | April 26. | ---- | 4.380 |
| Do. | 38 53.2 | 77 00.4 | 1881 | June 25, Dec. 17, 23. | 70 42.8 | ---- |
| Do. | 38 53.2 | 77 00.4 | 1882 | May.<br>June 15, 16, 17.<br>Sept. and Oct. | 70 47.8<br>70 44.1<br>70 45.2 | 4.364 |
| Do. | 38 53.2 | 77 00.4 | 1883 | June 18, July 5. | 70 40.8 | 4.373 |

*intensities in the United States and adjacent regions.—Continued.*

DISTRICT OF COLUMBIA—Continued.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| ---- | ° | | | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9; E. K. Kane's Mag. Obs's, Smithsonian Cont's to Know. |
| 13.51 | | | | Do. | C. & G. S. Rpt., 1881, App. 9. |
| 13.446 | | | | Do. | Do. |
| ---- | | | | S. Walker. | Do. |
| 13.368 | | | | C. A. Schott. | Do. |
| 13.351 | | | | Do. | Do. |
| ---- | | | | Do. | Do. |
| 13.93 | | | | W. Harkness. | Smithsonian Cont's to Know., No. 239, Wash., 1873. Dip apparently 1° too great; hence also F too great. |
| ---- | | | | Do. | MS. in C. & G. S. Office. |
| ---- | | | | Do. | Do. |
| | 70 55 | 4.395 | 13.20 | | |
| 13.347 | | | | C. A. Schott and E. Goodfellow. | C. & G. S. Rpt., 1881, App. 9. |
| 13.350 | | | | C. A. Schott. | Do. |
| ---- | | | | A. Hall. | MS. in C. & G. S. Office. |
| 13.328 | | | | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.315 | | | | Do. | Do. |
| 13.378 | | | | Do. | Do. |
| 13.399 | | | | Do. | Do. |
| 13.326 | | | | Do. | Do. |
| 13.272 | | | | Do. | Do. |
| 13.270 | | | | Do. | Do. |
| 13.238 | | | | C. A. Schott and F. E. Hilgard. | Do. |
| 13.292 | | | | C. A. Schott and A. Braid. | Do. |
| 13.282<br>13.248 | | | | C. A. Schott, T. E. Thorpe, and J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. For Dr. Thorpe's results see Proc. R. S., No. 200, 1880. |
| 13.292 | | | | W. Eimbeck and C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.258<br>13.275 | | | | J. B. Baylor. | Do. |
| ---- | | | | Do. | Do. |
| ---- | | | | S. W. Very. | Do. |
| 13.227 | | | | B. A. Colonna, W. Eimbeck. | C. & G. S. Rpt., 1881, App. 9, and MS. in C. & G. S. Office. |
| 13.218 | | | | C. A. Schott. | MS. in C. & G. S. Office. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

DISTRICT OF COLUMBIA—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Washington, magnetic observatory, Schott's garden, near corner of First and B streets southeast. | 38 53.2 | 77 00.4 | 1884 | Jan. and Feb. | 70 37.3<br>70 40.0 | 4.375 |
| Do. | 38 53.2 | 77 00.4 | 1884 | June 16, 17. | 70 33.2 | 4.396 |
| Do. | 38 53.2 | 77 00.4 | 1885 | June 13, 15. | 70 32.9 | 4.397 |
| Georgetown, West Washington. | 38 54 | 77 03 | 1844 | Apr. 10. | 71 19.0 | 4.277 |
| Causten, Georgetown Heights. | 38 55.5 | 77 04.5 | 1851 | June 9, 23. | 71 18.9 | 4.233 |
| Do. | 38 55.5 | 77 04.4 | 1855 | Sept. 8. | 71 30.2 | 4.250 |

FLORIDA.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Sand Key, Florida Reef. | 24 27.2 | 81 52.7 | 1849 | Aug. 18, 19, 22. | 54 25.8 | 6.758 |
| Key West, magnetic observatory. | 24 33.1 | 81 48.5 | 1860 | Feb., Mar., June, Dec. | 54 37.8 | 6.752 |
| Do. | 24 33.1 | 81 48.5 | 1861 | Feb., Mar., Apr. | 54 36.8 | 6.749 |
| Do. | 24 33.1 | 81 48.5 | 1862 | May to Dec. | 54 31.0 | 6.742 |
| Do. | 24 33.1 | 81 48.5 | 1863 | Jan. to Dec. | 54 31.2 | 6.740 |
| Do. | 24 33.1 | 81 48.5 | 1864 | Jan. to Dec. | 54 29.0 | 6.738 |
| Do. | 24 33.1 | 81 48.5 | 1865 | Jan. to Dec. | 54 28.8 | 6.729 |
| Do. | 24 33.1 | 81 48.5 | 1866 | Jan. to Apr. | 54 28.6 | 6.725 |
| Key West, grounds of Army Hospital. | 24 33.3 | 81 47.9 | 1879 | Mar. 24, 25; May 7 | 54 28.6 | 6.632 |
| Bird Key. | 24 37.3 | 82 53.6 | 1880 | Jan. 12, 13, 14. | 54 12.6 | 6.691 |
| Cape Florida. | 25 40.4 | 80 09.8 | 1850 | Feb. 22, 23, 26. | 56 13.0 | 6.615 |
| Hills, Hillsboro' River. | 26 15.5 | 80 04.7 | 1884 | Jan. 23. | 57 01.6 | ---- |
| Punta Rasa. | 26 29.3 | 82 00.6 | 1866 | June 28; July 2. | 57 12.3 | 6.583 |
| Fort Jupiter, ¾ of a mile southeast of light-house. | 26 54.5 | 80 05 | 1880 | Mar. 8. | 57 38.5 | 6.278 |
| House of Refuge No. 2, Indian River. | 27 12.0 | 80 09.8 | 1883 | Mar. 24. | 57 43.8 | 6.245 |
| Bell, Indian River. | 27 27.9 | 80 19.6 | 1883 | May 6. | 58 00.9 | 6.323 |
| Saint Lucie, on beach of Indian River. | 27 28.9 | 80 15 | 1880 | Mar. 2. | 58 16.8 | 6.297 |
| Eau Gallie, old agricultural college. | 28 09.4 | 80 37 | 1880 | Feb. 25. | 58 52.1 | 6.248 |
| Enterprise, rear of village. | 28 52.9 | 81 14 | 1880 | Feb. 18. | 60 07.5 | 6.053 |
| Depot Key, Cedar Keys. | 29 07.5 | 83 02.1 | 1852 | Mar. 14–24. | 59 55.3 | 6.179 |
| Apalachicola. | 29 43.2 | 84 59.0 | 1860 | Jan. 26; Feb. 4. | 60 19.4 | 6.185 |
| Saint Augustine, Government reservation. | 29 54 | 81 19 | 1880 | Feb. 11. | 61 09.2 | 5.925 |
| Jacksonville, hill north of town. | 30 21 | 81 40 | 1880 | Feb. 3. | 61 43.2 | 5.857 |
| Pensacola, public square. | 30 24.6 | 87 12.9 | 1858 | June 22, 23. | 61 05.9 | 6.127 |
| Pensacola, near Barkley station. | 30 24.6 | 87 12.5 | 1861 | Jan. 5–11. | 60 38.9 | 6.151 |
| Fernandina, geodetic station. | 30 40.6 | 81 27.6 | 1857 | Apr. 6, 10, 20. | 62 07.3 | 5.889 |
| Fernandina, Indian mound. | 30 40.3 | 81 27.3 | 1879 | Feb. 3–12. | 61 53.6 | 5.858 |
| Tallahassee. | 30 26 | 84 17 | 1835 | Jan. | 61 23 | ---- |

*intensities in the United States and adjacent regions.—Continued.*

DISTRICT OF COLUMBIA.—Continued.

| Total force F. | Referred results. $\theta_{1885\cdot0}$ | $H_{1885\cdot0}$ | $F_{1885\cdot0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| 13.185 | | | | J. E. Maxfield and W. Eimbeck. | MS. in C. & G. S. Office. |
| 13.204 | | | | C. A. Schott. | Do. |
| 13.205 | | | | Do. | Do. |
| 13.36 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke, papers of 1844. |
| 13.21 | 70 83 | 4.327 | 13.18 | G. W. Dean and A. D. Bache. | C. & G. S. Rpt., 1881, App. 9. |
| 13.40 | | | | C. A. Schott. | Do. |

FLORIDA.

| | | | | | |
|---|---|---|---|---|---|
| 11.62 | 54.33 | 6.73 | 11.54 | J. E. Hilgard. | C. & G. S. Rpt., 1881, App. 9. |
| 11.665 | | | | W. P. Trowbridge and S. Walker. | C. S. Rpt., 1874, App. 9. |
| 11.650 | | | | S. Walker and J. G. Oltmanns. | Do. |
| 11.620 | | | | S. Walker, J. G. Oltmanns, and F. F. Nes. | Do. |
| 11.612 | 54.43 | 6.628 | 11.40 | S. Walker. | Do. |
| 11.598 | | | | Do. | Do. |
| 11.582 | | | | Do. | Do. |
| 11.569 | | | | Do. | Do. |
| 11.41 | | | | S. M. Ackley. | C. & G. S. Rpt., 1881, App. 9. |
| 11.44 | 54.21 | 6.688 | 11.44 | Do. | Do. |
| 11.90 | 56.12 | 6.59 | 11.82 | J. E. Hilgard. | Do. |
| ---- | 57.03 | ---- | ---- | B. A. Colonna. | MS. in C. & G. S. Office. |
| 12.15 | 57.11 | 6.57 | 12.10 | A. T. Mosman. | C. & G. S. Rpt., 1881, App. 9. |
| 11.73 | 57.64 | 6.275 | 11.72 | J. B. Baylor. | Do. |
| 11.70 | 57.73 | 6.244 | 11.69 | B. A. Colonna. | MS. in C. & G. S. Office. |
| 11.94 | 58.01 | 6.322 | 11.93 | Do. | Do. |
| 11.98 | 58.28 | 6.294 | 11.97 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 12.08 | 58.87 | 6.245 | 12.08 | Do. | Do. |
| 12.15 | 60.12 | 6.050 | 12.14 | Do. | Do. |
| 12.33 | 59.83 | 6.16 | 12.26 | J. E. Hilgard. | Do. |
| 12.49 | 60.22 | 6.17 | 12.42 | G. W. Dean. | Do. |
| 12.28 | 61.15 | 5.923 | 12.28 | J. B. Baylor. | Do. |
| 12.36 | 61.72 | 5.855 | 12.36 | Do. | Do. |
| 12.68 | 60.80 | 6.13 | 12.57 | J. G. Oltmanns and F. H. Gerdes. | Do. |
| 12.55 | | | | G. W. Dean. | Do. |
| 12.59 | 61.93 | 5.87 | 12.48 | C. A. Schott. | Do. |
| 12.43 | | | | S. M. Ackley. | Do. |
| ---- | 61.30 | ---- | ---- | J. N. Nicollet. | C. S. Rpt., 1864, App. 19. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

GEORGIA.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Du Pont or Lawton, east of depot. | 30 57.8 | 82 47 | 1880 | Jan. 29. | 62 07.3 | 5.841 |
| Butler. | 31 17.7 | 81 20.8 | 1872 | Mar. 12–18; Apr. 15, 16. | 62 46.7 | 5.779 |
| Tybee Light-House. | 32 01.5 | 80. 50.7 | 1852 | Apr. 30; May 1, 2. | 63 40.8 | 5.618 |
| Do. | 32 01.5 | 80 50.7 | 1870 | May 21–26. | 63 27.0 | 5.682 |
| Savannah, Hutchinson's Island opposite city. | 32 05.2 | 81 05.3 | 1852 | Apr. 24–27. | 63 40.0 | 5.625 |
| Do. | 32 05.2 | 81 05.3 | 1857 | May 1, 2. | 63 44.3 | 5.664 |
| Do. | 32 05.2 | 81 05.3 | 1874 | Mar. 5–10. | 63 53.9 | 5.558 |
| Macon (Bibb County) Academy. | 32 50.4 | 83 37.5 | 1855 | Jan. 10–16. | 63 50.9 | 5.660 |
| Augusta. | 33 28 | 81 34 | 1833 | Feb. | ---- | 5.679 |
| Middle Base, near Atlanta. | 33 54.4 | 84 16.7 | 1872 | Oct., Nov. | 64 55.6 | 5.507 |
| Do. | 33 54.4 | 84 16.7 | 1873 | Feb. 8–13. | 64 58.5 | 5.489 |
| Athens. | 33 57 | 83 25 | {1833<br>1834 | May.<br>Sept. } | 65 40 | 4.568 |
| Kenesaw, about one-half mile east of geodetic station. | 33 58.6 | 84 34.8 | 1873 | Aug. 1, 2, 3. | 66 00.2 | 5.424 |
| Carnes, on a ridge south side of mountain. | 33 59.6 | 85 00.8 | 1873 | Dec. 20, 21, 22. | 65 09.6 | 5.468 |
| Sweat, foot of mountain. | 34 04.0 | 84 27.4 | 1873 | Oct. 9, 10. | 65 29.2 | 5.455 |
| Cumming, northeast part of town. | 34 12.4 | 84 07.7 | 1873 | Nov. 10–18. | 65 23.5 | 5.461 |
| Sawnee, summit of mountain. | 34 14.2 | 84 09.7 | 1873 | Nov. 1–14. | 65 26.0 | 5.412 |
| Pine Log, near geodetic station. | 34 19.3 | 84 38.3 | 1874 | Aug. 10, 11, 12. | 65 33.0 | 5.422 |
| Lavender, near geodetic station. | 34 19.3 | 85 17.4 | 1874 | Dec. 10, 11, 12. | 65 30.7 | 5.430 |
| Grassy, near geodetic station. | 34 29.2 | 84 20.0 | 1874 | July 24–31. | 65 41.8 | 5.192 |
| Currahee, south end of ridge on summit. | 34 31.8 | 83 22.6 | 1874 | Oct. 26, Nov. 11. | 65 45.1 | 5.282 |
| Johns, about two miles north of geodetic station. | 34 37.4 | 85 06.0 | 1875 | June 22, 23, 24. | 65 42.5 | 5.401 |

IDAHO TERRITORY.

| | | | | | | |
|---|---|---|---|---|---|---|
| Lewiston, Montgomery street, near Presbyterian church. | 46 28 | 117 05 | 1881 | Sept. 16, 17, 18. | 70 52.0 | 4.275 |
| Lake Pend d'Oreille Landing. | 47 58 | 116 30 | 1881 | Sept. 10, 11. | 72 26.0 | 4.006 |
| Sinyakwateen.* | 48 09 | 116 44 | 1860 | ---- | ---- | 3.991 |
| Do. | 48 09 | 116 44 | 1861 | May 31. | 72 34.9 | 4.0125 |
| Siniaquoteen,* near store-house. | 48 10.5 | 116 45 | 1881 | Sept. 5, 6. | 72 30.7 | 3.969 |
| Pack River. | 48 22 | 116 28 | 1861 | June 19. | 72 45.5 | 3.9683 |
| Chelemta River. | 48 41 | 116 19 | 1861 | June 23. | 73 08.0 | 3.9116 |
| Chelemta Depot. | 48 41 | 116 19 | 1861 | ---- | 73 06 | 3.902 |

ILLINOIS.

| | | | | | | |
|---|---|---|---|---|---|---|
| Cairo. | 37 00 | 89 10 | 1856 | Dec. 13. | 68 13 | 5.081 |
| Do. | 37 00 | 89 10 | 1872 | June 22. | 67 41.3 | 4.914 |
| Cairo, northwest of astronomical station. | 37 01.0 | 89 10.5 | 1877 | Nov. 28, 30. | 67 45.6 | 5.058 |

* Spelling unsettled.

***intensities in the United States and adjacent regions.**—Continued.*

GEORGIA.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 12.49 | ° 61.96 | 5.841 | 12.43 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 12.63 | 62.46 | 5.78 | 12.50 | A. T. Mosman. | Do. |
| 12.67 | 63.20 | 5.65 | 12.53 | J. E. Hilgard. | Do. |
| 12.71 | | | | C. O. Boutelle. | Do. |
| 12.68 | | | | J. E. Hilgard. | Do. |
| 12.80 | 63.41 | 5.62 | 12.56 | C. A. Schott. | Do. |
| 12.63 | | | | C. Tappan aud F. Blake. | Do. |
| 12.84 | 63.45 | 5.68 | 12.71 | G. W. Dean. | Do. |
| ---- | ---- | ---- | ---- | J. N. Nicollet. | C. S. Rpt., 1864. |
| 13.00 | 64.63 | 5.50 | 12.84 | F. P. Webber. | C. & G. S. Rpt., 1881, App. 9. |
| 12.98 | | | | Do. | Do. |
| ---- | 65.25 | ---- | ---- | J. N. Nicollet. | C. S. Rpt., 1864, App. 19. The dip is the mean of 3 det's corrected for index error, value of H mean of 3 det's. Epoch 1834.3 . |
| 13.34 | 65.69 | 5.44 | 13.21 | F. P. Webber. | C. & G. S. Rpt., 1881, App. 9. |
| 13.02 | 64.85 | 5.49 | 12.92 | Do. | Do. |
| 13.15 | 65.18 | 5.47 | 13.03 | Do. | Do. |
| 13.11 | 65.08 | 5.47 | 12.98 | H. W. Blair and C. O. Boutelle. | Do. |
| 13.02 | 65.12 | 5.42 | 12.88 | C. O. Boutelle. | Do. |
| 13.10 | 65.25 | 5.43 | 12.97 | F. P. Webber. | Do. |
| 13.10 | 65.21 | 5.44 | 12.97 | Do. | Do. |
| 12.62 | 65.40 | 5.20 | 12.49 | C. O. Boutelle. | Do. |
| 12.86 | 65.45 | 5.29 | 12.73 | Do. | Do. |
| 13.13 | 65.43 | 5.41 | 13.01 | F. P. Webber. | Do. |

IDAHO TERRITORY.

| | | | | | |
|---|---|---|---|---|---|
| 13.04 | 70.84 | 4.27 | 13.01 | J. S. Lawson. | C. & G. S. Rpt., 1881, App. 9. |
| 13.27 | 72.40 | 4.00 | 13.23 | Do. | Do. |
| ---- | | | | J. S. Harris. | U. S. N. W. Bound. Com. MS. in C. & G. S. Office. |
| 13.370 | 72.48 | 3.96 | 13.16 | R. W. Haig. | Bound. Sur., Phil. Trans. R. S., 1864. θ, H & F obs'd. |
| 13.21 | | | | J. S. Lawson. | C. & C. S. Rpt., 1881, App. 9. |
| 13.391 | 72.7 | ---- | ---- | R. W. Haig. | Bound. Sur., Phil. Trans. R. S., 1864. θ, H & F obs'd. |
| 13.469 | 73.1 | ---- | ---- | Do. | Do. |
| ---- | | | | J. S. Harris. | U. S. N. W. Bound. Com. MS. in C. &. G. S. Office. |

ILLINOIS.

| | | | | | |
|---|---|---|---|---|---|
| 13.693 | | | | K. Friesach. | Acad. Sc., Vienna, Vol. 29, 1858. |
| ---- | 67.44 | 5.06 | 13.19 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14. |
| 13.36 | | | | A. Braid. | C. & G. S. Rpt., 1881, App. 9. |

**TABLE I.—*Observed magnetic dips and horizontal and total magnetic***

ILLINOIS—Continued.

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Golconda. | 37 23 | 88 25 | 1871 | Aug., Oct. | 68 03.1 | ---- |
| Do. | 37 23 | 88 25 | 1872 | June 6–17. | 67 55.9 | 4.885 |
| East Saint Louis, grove opposite Bloody Island. | 38 37.5 | 90 11 | 1841 | Oct. 6. | 69 26.7 | ---- |
| Collinsville. | 38 39 | 90 04 | 1879 | Sept. 13. | 69 38.2 | 4.633 |
| Highland, Commons south of depot. | 38 45 | 89 41 | 1872 | Sept. 3. | 69 47.2 | 4.626 |
| Edwardsville, west of Court-House. | 38 50 | 89 53 | 1841 | Sept. | 69 57.7 | ---- |
| Alton, half mile from landing. | 38 54 | 90 04 | 1841 | Sept. | 69 34.8 | ---- |
| Upper Alton, east of college. | 38 55 | 90 03 | 1841 | Sept. | 69 45.7 | ---- |
| Monticello, near the Seminary. | 38 57 | 90 05 | 1841 | Sept. | 69 38.9 | ---- |
| Bunker Hill, one mile north of village. | 39 04 | 89 53 | 1841 | Sept. | 69 49.1 | ---- |
| Macon, pasture east of place of R. H. Woodcock. | 39 42 | 89 10 | 1872 | Sept. 1. | 70 13.5 | 4.475 |
| Springfield, grounds of Lincoln Monument. | 39 50 | 89 39 | 1878 | Dec. 3–7. | 70 25.5 | 4.497 |
| Beardstown. | 40 00 | 90 29 | 1880 | Aug. 9. | 70 18.6 | 4.476 |
| Copperas Creek, mouth of. | 40 30 | 89 48 | 1841 | Sept. | 70 56.4 | ---- |
| Pekin, near steamboat landing. | 40 35 | 89 36 | 1841 | Sept. | 71 13.2 | ---- |
| Wenona, grounds of J. R. Cowen. | 41 05 | 89 26 | 1872 | Aug. 29, 30. | 71 43.9 | 4.241 |
| Ottawa, one-quarter mile west of town, near bridge. | 41 15 | 88 50 | 1841 | Sept. | 72 20.2 | ---- |
| Peru, lower end of town, right bank of river. | 41 20 | 89 03 | 1841 | Sept. | 71 49.6 | ---- |
| Peru, near landing. | 41 23 | 89 05 | 1841 | Sept. | 71 51.1 | ---- |
| Joliet, oak grove near church on hill. | 41 30 | 88 09 | 1841 | Sept. | 72 16.0 | ---- |
| Rock Island, near astronomical post. | 41 31.1 | 90 33.7 | 1878 | Sept. 15–20; Oct. 5, 7. | 72 15.3 | 4.2079 |
| Mount Forest, near astronomical post. | 41 44.7 | 87 51.9 | 1876 | Aug. 29; Sept. 2. | 71 52.8 | 3.9713 |
| Chicago, north side of Chicago River, near lake. | 41 53 | 87 38 | 1841 | Sept. | 72 45.8 | ---- |
| Chicago, one mile north of town. | 41 53 | 87 38 | 1841 | Sept. | 72 47.8 | ---- |
| Chicago, Dr. Eldridge's garden. | 41 53 | 87 38 | 1842 | Nov. 15, 16. | 72 39.3 | 4.105 |
| Chicago, grounds of Chicago University. | 41 50.0 | 87 36.7 | 1878 | Sept. 2. | 72 39.4 | 4.067 |
| Rockford, near park. | 42 17.0 | 89 06.6 | 1876 | Oct. 6–11. | 72 48.3 | 4.0827 |
| Galena, near astronomical post. | 42 25.2 | 90 25.9 | 1876 | Sept. 28, 29. | 73 09.0 | 3.9926 |
| Galena, hill back of town. | 42 28 | 90 26 | 1841 | Sept. | 73 02.1 | ---- |
| Dunleith. | 42 28 | 90 40 | 1856 | Oct. 18. | 73 10 | ---- |

INDIANA.

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Mount Vernon. | 37 59 | 87 47 | 1840 | Sept. 10. | 68 56.3 | 4.841 |
| New Harmony. | 38 10 | 87 48 | 1840 | Sept. 11. | 69 03.6 | 4.812 |
| Do. | 38 08 | 87 50 | 1848 | Nov. 12, 13. | 69 07.2 | 4.843 |
| New Harmony, center of common, Main street. | 38 08 | 87 50 | 1880 | Nov. 3, 5. | 69 02.6 | 4.762 |
| New Albany, on hill in cemetery. | 38 20 | 85 47 | 1871 | Nov. 28. | 70 21.9 | 4.466 |
| Princeton. | 38 23 | 87 30 | 1840 | Sept. 16. | 69 22.8 | 4.751 |
| Paoli. | 38 35 | 86 25 | 1840 | Sept. 20. | 69 33.8 | 4.692 |

*intensities in the United States and adjacent regions.—Continued.*

ILLINOIS—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| ---- | 67.66 | 4.89 | 12.87 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14. |
| ---- | | | | Do. | Do. |
| ---- | 69.10 | ---- | ---- | J. N. Nicollet. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | 69.46 | 4.63 | 13.20 | F. E. Nipher. | St. Louis Acad. Sc. |
| ---- | 69.47 | 4.63 | 13.20 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14. |
| ---- | 69.61 | ---- | ---- | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | | | | | |
| ---- | 69.31 | ---- | ---- | Do. | Do. |
| ---- | | | | | |
| ---- | 69.47 | ---- | ---- | Do. | Do. |
| ---- | 69.91 | 4.48 | 13.05 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14. |
| 13.42 | 70.22 | 4.50 | 13.29 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 70.16 | 4.48 | 13.20 | F. E. Nipher. | St. Louis Acad. Sc. |
| ---- | 70.59 | ---- | ---- | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | 70.87 | ---- | ---- | Do. | Do. |
| ---- | 71.41 | 4.24 | 13.30 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14. |
| ---- | 71.99 | ---- | ---- | J. N. Nicollet. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | 71.49 | ---- | ---- | Do. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | | | | E. Loomis. | Do. |
| ---- | 71.92 | ---- | ---- | J. N. Nicollet. | Do. |
| 13.806 | 72.05 | 4.21 | 13.66 | C. F. Powell. | Rpt. Chief of Engineers, U. S. A., 1877, pt. 2. |
| 12.770 | 71.62 | 3.97 | (12.59) | D. W. Lockwood. | Do. |
| ---- | | | | J. N. Nicollet. | Am. Phil. Soc., Vol. VIII, pt. 3, 1843. |
| ---- | | | | E. Loomis. | Do. |
| 13.778 | 72.41 | 4.07 | 13.48 | C. Younghusband. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ H F obs'd. |
| 13.644 | | | | T. E. Thorpe. | Proc. R. S., No. 200, 1880. |
| 13.810 | 72.54 | 4.08 | 13.60 | C. F. Powell. | Rpt. Chief of Engineers, U. S. A., 1877, pt. 2. |
| 13.774 | 72.79 | 3.99 | 13.49 | Do. | Rpt. Chief of Engineers, U. S. A., 1877, pt. 2. Local disturbance suspected. |
| ---- | | | | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | 72.77 | ---- | ---- | K. Friesach. | Acad. Sc. Vienna, Vol. XXIX, 1858. |

INDIANA.

| | | | | | |
|---|---|---|---|---|---|
| 13.47 | 68.59 | ---- | ---- | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.47 | | | | Do. | Do. |
| 13.59 | 68.79 | 4.76 | 13.16 | R. H. Fauntleroy. | C. & G. S. Rpt., 1881, App. 9. |
| 13.31 | | | | J. B. Baylor. | Do. |
| ---- | 70.01 | 4.47 | 13.08 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| 13.49 | 69.03 | ---- | ---- | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.44 | 69.21 | ---- | ---- | Do. | Do. |

**TABLE I.—*Observed magnetic dips and horizontal and total magnetic***

INDIANA—Continued.

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Vincennes. | 38 40.6 | 87 31.5 | 1840 | Sept. 18. | 69 51.2 | 4.665 |
| Vincennes, ½ mile above lower ferry. | 38 40.6 | 87 31.5 | 1841 | Oct. | 69 52.8 | ---- |
| Vincennes, southwest corner of Catholic cemetery. | 38 41.7 | 87 31.6 | 1880 | Oct. 29, 30. | 69 50.4 | 4.632 |
| Terre Haute. | 39 28 | 87 20 | 1874 | Aug. 29. | 70 34.7 | 4.505 |
| Indianapolis, fair grounds north of city. | 39 47.4 | 86 08 | 1880 | Nov. 12, 13. | 70 51.4 | 4.370 |
| Richmond. | 39 49 | 84 47 | 1845 | ---- | 71 20.3 | ---- |
| Richmond, Front street. | 39 50 | 84 50 | 1871 | Nov. 24. | 71 26.6 | ---- |
| Richmond, Court House Square. | 39 50.4 | 84 50 | 1880 | Nov. 19, 20. | 71 13.4 | 4.354 |
| Reynolds. | 40 45 | 86 48 | 1874 | Aug. 27. | 72 00 | 4.212 |
| Fort Wayne, in fair grounds. | 41 06.3 | 85 03 | 1874 | Aug. 24. | 72 19.0 | 4.218 |
| Michigan City, near light-house. | 41 43 | 86 54 | 1859 | Aug. 28. | 73 02 | 4.013 |
| Michigan City, on beach near light-house. | 41 43 | 86 54 | 1873 | Aug. 25, 26. | 72 43 | 4.091 |

INDIAN TERRITORY.

| | | | | | | |
|---|---|---|---|---|---|---|
| Atoka, north of and near J. Harden's house. | 34 24.5 | 96 05 | 1878 | July 13–17. | 63 44.8 | 5.670 |
| Vinita, on premises of Dr. Trott. | 36 39.5 | 95 05.0 | 1877 | Nov. 22, 23, 24. | 66 31.8 | 5.284 |
| Vinita. | 36 41.4 | 95 07.1 | 1878 | Sept. 9. | 66 39.5 | 4.936 |

IOWA.

| | | | | | | |
|---|---|---|---|---|---|---|
| Keokuk, corner of Second and Blondeau streets. | 40 25.5 | 91 25.0 | 1877 | Nov. 6, 7, 8. | 70 47.2 | 4.506 |
| Keokuk. | 40 24.8 | 91 28.0 | 1878 | July 29, 30, 31. | 70 46.7 | 4.419 |
| Council Bluffs, near railroad depot. | 41 15.3 | 95 52.4 | 1878 | Aug. 30. | 71 05.7 | 4.3663 |
| Engineer cantonment. | 41 25 | 95 44 | 1820 | ---- | 71 07 | ---- |
| Davenport. | 41 30 | 90 38 | 1839 | Sept. 13. | 71 55 | 4.278 |
| Do. | 41 30 | 90 40 | 1839 | Sept. 15. | 71 55.2 | 4.269 |
| Davenport, near corner of Seventh and Scott streets. | 41 29.9 | 90 38.0 | 1877 | Oct. 27–30. | 71 56.6 | 4.274 |
| Des Moines. | 41 35.0 | 94 37.4 | 1869 | Aug. 9. | 71 13 | 4.313 |
| Des Moines, Chestnut street between Fifth and Sixth. | 41 35 | 93 37 | 1872 | Nov. 4. | 71 30.4 | 4.228 |
| Des Moines, corner Ninth and Sycamore streets. | 41 36.8 | 93 36.5 | 1877 | Oct. 23, 24, 25. | 71 31.0 | 4.330 |
| Lost Grove. | 41 39 | 90 09 | 1839 | Sept. 23. | 72 02.4 | 4.260 |
| Iowa City, Nipher's farm, 4 miles west. | 41 39.7 | 91 35.5 | 1878 | June 16. | 72 02.8 | ---- |
| Iowa City, grounds of University. | 41 39.7 | 91 31.5 | 1878 | July 2–7. | 72 19.7 | 4.118 |
| Iowa City, Nipher's farm, 4 miles west. | 41 39.7 | 91 35.5 | 1879 | July 6, 7–11. | 72 02.7 | 4.128 |

*intensities in the United States and adjacent regions.—Continued.*

INDIANA—Continued.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| 13.55 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | 69.57 | 4.63 | 13.27 | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| 13.44 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 70.28 | 4.51 | 13.37 | F. E. Hilgard and W. Diehl. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| 13.33 | 70.71 | 4.37 | 13.23 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | J. Locke. | Phil. Trans. R. S., 1846. |
| ---- | 71.06 | 4.35 | 13.40 | T. C. Hilgard. | C. & G. S. Rept., 1882, App. 14, Nat. Acad. Ser. |
| 13.53 | | | | J. B. Baylor. | C. & G. S. Rept., 1881, App. 9. |
| ---- | 71.70 | 4.21 | 13.41 | F. E. Hilgard and W. Diehl. | C. & G. S. Rept., 1882, App. 14, Nat. Acad. Ser. |
| ---- | 72.02 | 4.22 | 13.67 | Do. | Do. |
| 13.789 | 72.52 | 4.09 | 13.62 | W. P. Smith. | U. S. Lake Sur., Capt. G. G. Meade, Detroit, 1859, and Rpt. of 1882. |
| 13.770 | | | | A. N. Lee. | U. S. Lake Sur., Rpt. of 1882. |

INDIAN TERRITORY.

| | | | | | |
|---|---|---|---|---|---|
| 12.82 | 63.64 | 5.67 | 12.77 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.27 | 66.47 | 5.11 | 12.80 | A. Braid. | Do. |
| ---- | | | | F. E. Nipher. | St. Louis Acad. Sci. |

IOWA.

| | | | | | |
|---|---|---|---|---|---|
| 13.69 | 70.72 | 4.46 | 13.51 | A. Braid. | C. & G. S. Rpt., 1881. App. 9. |
| ---- | | | | F. E. Nipher. | St. Louis Acad. Sc. |
| 13.476 | 71.09 | 4.37 | 13.49 | T. E. Thorpe. | Proc. R. S., No. 200, 1880. |
| ---- | | | | S. H. Long, U. S. A. | Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823; Sill, J., Vol. XXXIV, 1838. |
| 13.78 | | | | J. Locke. | Sill. J., 1840; Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's papers of 1844. |
| 13.76 | 71.9 | 4.27 | 13.74 | Do. | Am. Phil. Soc., 1846, Art, XI, Dr. J. Locke's papers of 1844. |
| 13.79 | | | | A. Braid. | C. & G. S. Rpt., 1881, App. 9. |
| 13.40 | | | | J. E. Hilgard. | Do. |
| ---- | 71.44 | 4.33 | 13.61 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14., Nat. Acad. Ser. |
| 13.66 | | | | A. Braid. | C. & G. S. Rpt., 1881, App. 9. |
| 13.81 | 71.9 | ---- | ---- | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | | | | | St. Louis Acad. Sc. |
| ---- | 72.07 | 4.13 | 13.42 | F. E. Nipher. | Do. |
| ---- | | | | | MS. dated July 19, 1879, in C. & G. S. Office. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

IOWA—Continued.

| Name of station. | Latutude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Wapsipinicon. | 41 44 | 90 23 | 1839 | Sept. 25. | 72 15.0 | 4.234 |
| Iron Ore Bed. | 41 55 | 90 40 | 1839 | Sept. 27. | 72 50.5 | 4.135 |
| Brown's Settlement. | 42 02 | 91 06 | 1839 | Sept. 30. | 72 21 | 4.179 |
| Iowa Station. | 42 04 | 91 02 | 1839 | ---- | 72 24.4 | ---- |
| Farmer's Creek. | 42 13 | 90 23 | 1839 | Oct. 5. | 72 36 | 4.162 |
| Maquoketa River. | 42 14 | 90 55 | 1839 | Oct. 2. | 72 43.6 | 4.112 |
| White Water. | 42 18 | 90 38 | 1839 | Oct. 8. | 72 55 | 4.063 |
| Maquoketa, north branch. | 42 23 | 90 52 | 1839 | Oct. 9. | 72 51 | 4.049 |
| Dubuque. | 42 29 | 90 40 | 1839 | Oct. 14. | 73 05 | 4.008 |
| Dubuque, on Seminary Hill. | 42 30 | 90 45 | 1872 | Aug. 24–27. | 73 06.8 | 3.933 |
| Dubuque. | 42 29.5 | 90 44 | 1880 | Oct. 21, 22. | 73 07.8 | 3.972 |
| Forks of Little Maquoketa. | 42 31 | 90 31 | 1839 | Oct. 20. | 73 08 | 4.011 |
| Turkey River. | 42 42 | 90 48 | 1839 | Oct. 22. | 73 11 | 3.974 |
| Sibley, yard of Sibley House. | 43 24.1 | 95 50.0 | 1877 | Oct. 8, 9, 10. | 72 59.3 | 4.053 |
| **KANSAS.** | | | | | | |
| Parsons. | 37 20.0 | 95 17.4 | 1879 | Aug. 26. | 67 12.4 | 5.080 |
| Sargent, north of railroad, west of Hardesty House. | 38 05.2 | 101 58.5 | 1878 | Aug. 8–10–12. | 66 50.5 | 5.129 |
| Great Bend, west of school-house. | 38 23.6 | 98 43.1 | 1878 | July 30, 31, Aug. 1, 2. | 67 38.0 | 4.988 |
| Wallace. | 38 55 | 101 35 | 1872 | Oct. 12. | 67 31.6 | 4.956 |
| Ellis. | 38 56 | 99 40 | 1872 | Oct. 10. | 67 51.7 | 4.934 |
| Lawrence, grounds of Old University. | 38 57.7 | 95 15.0 | 1877 | Nov. 14–17. | 68 43.4 | 4.866 |
| Manhattan, College grounds. | 39 12 | 96 35 | 1872 | Oct. 7. | 68 47.2 | 4.773 |
| Fort Leavenworth. | 39 21 | 94 54 | 1858 | ---- | 69 29 | ---- |
| Little Muddy Creek. | 39 35 | 95 34 | 1858 | ---- | 69 35 | ---- |
| Vermillion Creek. | 39 57 | 96 16 | 1858 | ---- | 70 09 | ---- |
| Big Blue River. | 40 00 | 96 35 | 1858 | ---- | 69 19 | ---- |
| **KENTUCKY.** | | | | | | |
| Hickman, court-house grounds. | 36 34.3 | 89 11.7 | 1881 | Sept. 23, 24. | 67 19.4 | 5.071 |
| Mayfield, court-house square. | 36 45 | 88 41 | 1881 | Sept. 27, 28. | 67 35.0 | 5.008 |
| Williamsburg, court-house place. | 36 47 | 84 10 | 1873 | Aug. 14. | 68 25.7 | 4.933 |
| Oakland, near astronomical station. | 37 02.4 | 86 15.3 | 1871 | Nov. 6, 10. | 68 48.8 | 4.877 |
| Smithland. | 37 08 | 88 30 | 1833 | Dec. | 68 11 | ---- |
| Mammoth Cave, at the mouth, near house. | 37 10 | 86 11 | 1849 | June 14. | 69 18.5 | ---- |
| Madisonville, court-house square. | 37 19 | 87 33 | 1881 | Oct. 4, 5. | 68 24.2 | 4.915 |
| Livingston, meadow west of Sand Brook Hotel | 37 23 | 84 20 | 1881 | Oct. 20, 21. | 68 50.3 | 4.817 |
| Leitchfield, court-house square. | 37 30 | 86 22 | 1881 | Oct. 7, 8. | 68 38.2 | 4.892 |

*intensities in the United States and adjacent regions.—Continued.*

IOWA—Continued.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| 13.89 | 72.2 | ---- | ---- | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 14.02 | 72.7 | ---- | ---- | Do. | Do. |
| 13.78 | 72.2 | ---- | ---- | Do. | Do. |
| ---- | | | | | Sill, J., 1840. |
| 13.92 | 72.4 | ---- | ---- | Do. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.85 | 72.6 | ---- | ---- | Do. | Do. |
| 13.83 | 72.7 | ---- | ---- | Do. | Do. |
| 13.74 | 72.7 | ---- | ---- | Do. | Do. |
| 13.77 | 72.97 | 3.97 | 13.56 | Do. | Sill, J., 1840, E. Loomis; Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | | | | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| 13.69 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.82 | 73.0 | ---- | ---- | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.74 | 73.0 | ---- | ---- | Do. | Do. |
| 13.85 | 72.87 | 4.05 | 13.75 | A. Braid. | C. & G. S. Rpt., 1881, App. 9. |

KANSAS.

| | | | | | |
|---|---|---|---|---|---|
| ---- | 67.12 | 5.08 | 13.07 | F. E. Nipher. | St. Louis Acad. Sc. |
| 13.04 | 66.74 | 5.13 | 12.99 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.11 | 67.52 | 4.99 | 13.05 | Do. | Do. |
| ---- | 67.37 | 4.96 | 12.89 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| ---- | 67.70 | 4.93 | 12.99 | Do. | Do. |
| 13.41 | 68.60 | 4.87 | 13.35 | A. Braid. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 68.63 | 4.77 | 13.09 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| ---- | 69.3 | ---- | ---- | J. H. Simpson. | Explor's by Capt. Simpson, U. S. E. Stone's Mag. Var's., New York, 1878. |
| ---- | 69.4 | ---- | ---- | Do. | Do. |
| ---- | 69.9 | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |

KENTUCKY.

| | | | | | |
|---|---|---|---|---|---|
| 13.15 | 67.20 | 5.07 | 13.08 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.13 | 67.46 | 5.01 | 13.07 | Do. | Do. |
| ---- | 68.12 | 4.94 | 13.26 | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| 13.49 | 68.47 | 4.88 | 13.30 | A. T. Mosman and E. Smith. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 67.77 | ---- | ---- | J. N. Nicollet. | C. S. Rpt., 1864, App. 19. |
| 13.415 | 68.95 | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur., Canada, Sir J. H. Lefroy, London, 1883. |
| 13.35 | 68.28 | 4.92 | 13.30 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.34 | 68.72 | 4.82 | 13.28 | Do. | Do. |
| 13.43 | 68.52 | 4.89 | 13.35 | Do. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

KENTUCKY—Continued.

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Stanford, court-house grounds. | 37 31 | 84 44 | 1881 | Oct. 15, 16, 17. | 69 43.8 | 4.625 |
| Lebanon, yard of Norris Hotel. | 37 36 | 85 19 | 1881 | Oct. 11, 12, 13. | 69 06.8 | 4.750 |
| Clay's Ferry. | 37 54 | 84 18 | 1840 | Sept. 3. | 69 49.0 | 4.639 |
| Lexington. | 38 06 | 84 18 | 1840 | Sept. 2. | 69 54.5 | 4.603 |
| Shelbyville, east of Observatory. | 38 12.8 | 85 13.2 | 1871 | Nov. 27; Dec. 2. | 69 46.6 | 4.660 |
| Frankfort. | 38 14 | 84 40 | 1840 | Sept. 4. | 69 54.9 | 4.616 |
| Shippingport. | 38 15 | 85 30 | 1819 | May 20. | 70 15 | ---- |
| Louisville. | 38 15 | 85 46 | 1839 | ---- | 70 08 | ---- |
| Do. | 38 15 | 85 46 | 1840 | Mar. 11. | { 69 56<br>69 54.4 | } 4.654 |
| Louisville, in Jacob's Wood. | 38 15 | 85 46 | 1849 | June 18. | 69 55.5 | ---- |
| Louisville. | 38 15.1 | 85 45.5 | 1856 | Nov. 23. | 70 08 | ---- |
| Grayson, lot east of E. K. R. R. depot. | 38 18 | 82 59 | 1881 | Nov. 5, 6. | 70 09.3 | 4.643 |
| Cynthiana, near Protestant cemetery. | 38 26 | 84 25 | 1881 | Oct. 25, 26. | 69 44.0 | 4.626 |
| Flemingsburg, public-school grounds. | 38 26 | 83 46 | 1881 | Oct. 31; Nov. 1. | 69 45.2 | 4.627 |
| Williamstown. | 38 36 | 84 22 | 1840 | Sept. 1. | 70 04.1 | 4.603 |
| Falmouth, Coleman's Farm. | 38 40.8 | 84 17.3 | 1872 | Dec. 30; Jan. 9. | 70 16.1 | 4.580 |
| **LOUISIANA.** | | | | | | |
| Southwest Pass, Mississippi Delta. | 28 59 | 89 23 | 1840 | ---- | 58 42.2 | ---- |
| Southwest Pass, Mississippi Delta, near Stake Island. | 28 59 | 89 23 | 1872 | Mar. 2. | 58 46.5 | 6.209 |
| Southeast Pass, Mississippi Delta. | 29 04.7 | 89 03.6 | 1859 | Dec. 21. | 58 45.3 | 6.377 |
| Cubitt. | 29 09.9 | 89 14.6 | 1859 | Dec. 16. | 58 54.0 | 6.342 |
| Pass à Loutre. | 29 10.9 | 89 01.4 | 1859 | Dec. 27. | 58 47.0 | 6.355 |
| Osgood Island, southeast by east of Pass à Loutre Light. | 29 11.3 | 89 05.3 | 1872 | Mar. 4, 5. | 59 01.2 | 6.068 |
| Magnolia base, lower station. | 29 32.5 | 89 46.6 | 1872 | Jan. 17. | 59 23.5 | 5.977 |
| Brashear City, old earthworks north of town. | 29 41 | 91 14 | 1872 | Mar. 23. | 59 16.3 | 6.093 |
| Côte Blanche. | 29 44.1 | 91 42.9 | 1860 | Mar. 3, 4. | 59 08.8 | 6.349 |
| Barrel Key. | 29 54.3 | 89 08.0 | 1857 | Apr. 14, 18. | 59 48.2 | 6.282 |
| Avery's Island, six and one-half miles southwest of New Iberia. | 29 55 | 91 45 | 1872 | Mar. 13–19. | 59 26.4 | 6.012 |
| New Orleans Mint. | 29 57.7 | 90 03.4 | 1834 | Aug. | 60 15 | ---- |
| New Orleans. | 29 58 | 90 04 | 1856 | Dec. 18, 24. | 59 30 | 6.350 |
| New Orleans, Basin and Canal streets. | 29 57.4 | 90 04.4 | 1858 | Apr. 7, 10. | 59 46.5 | 6.310 |
| New Orleans, city park. | 29 55.6 | 90 07.8 | 1872 | Feb. 10–15. | 59 43.5 | 5.959 |
| New Orleans, fair grounds station. | 29 59.1 | 90 04.8 | 1872 | Feb. 14. | 59 48.6 | ---- |
| Do. | 29 59.1 | 90 04.8 | 1880 | Mar. 24, 25. | 59 48.6 | 6.155 |
| Baton Rouge, mound south of college. | 30 26 | 91 12 | 1872 | Apr. 1–6. | 60 20.0 | 6.008 |

*intensities in the United States and adjacent regions.—Continued.*

KENTUCKY—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| 13.35 | 69.61 | 4.63 | 13.29 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.32 | 69.00 | 4.75 | 13.26 | Do. | Do. |
| 13.45 | 69.47 | ---- | ---- | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.41 | 69.56 | ---- | ---- | Do. | Do. |
| 13.48 | 69.45 | 4.67 | 13.31 | A. T. Mosman and E. Smith. | C. & G. S. Rpt., 1881, App. 9. |
| 13.45 | 69.56 | ---- | ---- | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | 69.55 | ---- | --- | S. H. Long. | Maj. Long's Exp. to Rocky Mts., 2 vols. Phila., 1823. |
| ---- | | | | J. Locke. | Sill. J., 1840. |
| 13.55 | 69.64 | 4.66 | 13.40 | Do. | Sill. J., 1840; Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.574 | | | | J. H. Lefroy. | Diary Mag. Sur., Canada, Sir J. H. Lefroy, London, 1883. |
| ---- | | | | K. Friesach. | K. K. Acad. d. Wiss, Vienna, vol. 29, 1858. |
| 13.68 | 70.04 | 4.65 | 13.62 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.36 | 69.61 | 4.63 | 13.29 | Do. | Do. |
| 13.37 | 69.63 | 4.63 | 13.30 | Do. | Do. |
| 13.50 | 69.72 | ---- | ---- | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.57 | 69.95 | 4.59 | 13.39 | E. Goodfellow. | C. & G. S. Rpt., 1881, App. 9. |

LOUISIANA.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| ---- | 58.8 | 6.154 | 11.88 | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| 12.00 | | | | T. C. Hilgard. | C. & G. S. Rpt., 1881, App. 9; also Rpt. 1882, App. 14. |
| 12.29 | 58.8 | 6.28 | 12.12 | F. H. Gerdes and J. G. Oltmanns. | C. & G. S. Rpt., 1881, App. 9. |
| 12.28 | 59.0 | 6.24 | 12.12 | Do. | Do. |
| 12.26 | 58.9 | 6.07 | 11.75 | Do. | Do. |
| ---- | | | | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| 11.74 | 59.4 | 5.924 | 11.64 | Do. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 59.3 | 6.040 | 11.83 | Do. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| 12.38 | 59.1 | 6.25 | 12.17 | F. H. Gerdes and J. G. Oltmanns. | C. & G. S. Rpt., 1881, App. 9. |
| 12.49 | 59.8 | 6.17 | 12.27 | S. Harris. | Do. |
| ---- | 59.5 | 5.959 | 11.74 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| ---- | | | | J. N. Nicollet. | C. S. Rpt., 1864, App. 19. |
| 12.512 | | | | K. Friesach. | K. K. Acad. d. Wiss., Vienna, vol. 29, 1858. H & F were converted into Eng. units. |
| 12.54 | 59.8 | 6.021 | 11.97 | G. W. Dean. | C. & G. S. Rpt., 1881, App. 9. |
| 11.84 | | | | T. C. Hilgard. | C. & G. S. Rpt., 1881, App. 9; also Rpt. 1882, App. 14. |
| ---- | | | | Do. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| 12.24 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9; also Rpt. 1882, App. 14. |
| ---- | 60.4 | 5.955 | 12.06 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

LOUISIANA—Continued.

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Alexandria, Irwin's pasture. | 31 17 | 92 27 | 1872 | Apr. 18. | 60 53.0 | 5.965 |
| Gaines Ferry. | 31 28 | 93 45 | 1840 | May. | 60 57.0 | ---- |
| Natchitoches. | 31 44 | 93 05 | 1834 | Apr. | 62 11 | ---- |
| Do. | 31 44 | 93 07 | 1840 | June. | 61 15.9 | ---- |
| Grand Ecore, breastwork in front of hotel. | 31 48 | 93 07 | 1872 | Apr. 10. | 61 27.2 | 5.901 |
| Sabine River. | 32 01 | 94 00 | 1840 | ---- | 61 36.8 | ---- |
| Monroe. | 32 29 | 92 08 | 1872 | Apr. 26. | ---- | 5.778 |
| Shreveport, river front, Jones' Hill. | 32 30 | 93 45 | 1872 | Apr. 14. | 62 04.4 | 5.809 |

MAINE.

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Kittery Point, opposite Portsmouth, N. H. | 43 04.8 | 70 43.0 | 1850 | Aug. 29; Sept. 4. | 74 57.2 | 3.500 |
| Kittery Point. | 43 04.8 | 70 43.0 | 1859 | July 14. | 75 04.2 | 3.496 |
| Do. | 43 04.8 | 70 43.0 | 1879 | Aug. 13, 14. | 74 26.2 | 3.588 |
| Cape Neddick. | 43 11.6 | 70 36.4 | 1851 | Aug. 28, 29, 30. | 74 57.9 | 3.516 |
| Agamenticus. | 43 13.4 | 70 41.5 | 1847 | Sept., Oct., Nov. | 74 54.7 | 3.456 |
| Kennebunkport. | 43 21.4 | 70 28.1 | 1851 | Aug. 23, 27. | 75 14.1 | 3.448 |
| Fletcher's Neck. | 43 26.8 | 70 20.5 | 1850 | Sept. 9, 12. | 75 18.3 | 3.440 |
| Richmond Island. | 43 32.6 | 70 14.4 | 1850 | Sept. 14, 16. | 75 08.0 | 3.464 |
| Portland. | 43 41 | 70 20 | 1845 | June 2. | 75 13.7 | 3.427 |
| Portland, Bramhall or Bowdoin Hill. | 43 38.8 | 70 16.6 | 1851 | Aug. 15, 20. | 75 14.1 | 3.450 |
| Do. | 43 38.8 | 70 16.6 | 1859 | July 15. | 74 56.7 | 3.456 |
| Portland, Munjoy's Hill. | 43 39.9 | 70 14.9 | 1863 | July 6. | 75 04.6 | 3.425 |
| Portland, Bramhall Hill. | 43 38.8 | 70 16.6 | 1863 | July 15. | 75 05.9 | 3.439 |
| Do. | 43 38.8 | 70 16.6 | 1864 | Aug. to Dec. | 75 09.5 | 3.456 |
| Do. | 43 38.8 | 70 16.6 | 1865 | Jan. to Dec. | 75 08.3 | 3.459 |
| Do. | 43 38.8 | 70 16.6 | 1866 | Jan. to Mar. | 75 07.4 | 3.458 |
| Portland, Munjoy's Hill. | 43 39.9 | 70 14.9 | 1873 | Sept. 8, 11. | 74 57.9 | 3.472 |
| Harpswell. | 43 44.5 | 70 00.8 | 1863 | July 22. | 75 52.4 | 3.184 |
| Mount Independence. | 43 45.5 | 70 19.2 | 1849 | Oct. 9–16. | 75 23.8 | 3.422 |
| Cape Small. | 43 46.7 | 69 50.7 | 1851 | Oct. 16–25. | 75 01.8 | 3.389 |
| Freeport. | 43 51.1 | 70 05.9 | 1863 | July 13. | 75 20.3 | 3.395 |
| Brunswick. | 43 54.5 | 69 57.7 | 1873 | Sept. 13–17. | 75 08.3 | 3.437 |
| Bath. | 43 54.9 | 69 49.0 | 1863 | July 11. | 75 25.5 | 3.355 |
| Mount Pleasant. | 44 01.6 | 70 49.3 | 1851 | Aug. 6–27. | 76 01.5 | 3.212 |
| Rockland. | 44 06.3 | 69 06.2 | 1863 | July 7. | 75 30.9 | 3.318 |
| Mount Sebattis. | 44 09.1 | 70 04.8 | 1853 | July 25–29. | 75 40.6 | 3.411 |
| Camden Village. | 44 12 | 69 05 | 1854 | Oct. 26–Nov. 4. | 75 41.5 | 3.345 |
| Mount Ragged. | 44 12.8 | 69 09.1 | 1854 | Sept. 22–26. | 75 41.2 | 3.345 |
| Southwest Harbor, Mount Desert Island. | 44 15.0 | 68 17.6 | 1856 | Sept. 25–30. | 76 15.5 | 3.280 |
| Mount Desert. | 44 21.1 | 68 13.6 | 1856 | Oct. 7–13. | 76 09.2 | 3.255 |

*intensities in the United States and adjacent regions.—Continued.*

LOUISIANA—Continued.

| Total force F. | Referred results. $\theta_{1885\cdot0}$ | $H_{1885\cdot0}$ | $F_{1885\cdot0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| ---- | 60.9 | 5.912 | 12.16 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| ---- | 61.0 | ---- | ---- | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| ---- | 61.4 | ---- | ---- | J. N. Nicollet. | C. S. Rpt. 1864, App. 19. |
| ---- | | | | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| ---- | 61.5 | 5.848 | 12.26 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| ---- | 61.6 | ---- | ---- | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| ---- | ---- | 5.725 | ---- | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| ---- | 62.1 | 5.756 | 12.30 | Do. | Do. |

MAINE.

| Total force F. | $\theta_{1885\cdot0}$ | $H_{1885\cdot0}$ | $F_{1885\cdot0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 13.48 | | | | J. E. Hilgard. | C. & G. S. Rpt., 1881, App. 9. |
| 13.57 | 73.98 | 3.611 | 13.09 | C. A. Schott. | Do. |
| 13.37 | | | | J. B. Baylor. | Do. |
| 13.55 | 74.03 | 3.634 | 13.21 | J. E. Hilgard. | Do. |
| 13.28 | 74.01 | 3.540 | 12.85 | T. J. Lee and R. H. Fauntleroy. | Do. |
| 13.53 | 74.30 | 3.567 | 13.18 | J. E. Hilgard. | Do. |
| 13.56 | 74.38 | 3.550 | 13.18 | Do. | Do. |
| 13.50 | 74.21 | 3.574 | 13.13 | Do. | Do. |
| 13.44 | | | | J. Locke. | Phil. Trans. R. S., 1846; Smithsonian Cont's to Know., Vol. III, 1852. |
| 13.54 | | | | J. E. Hilgard. | C. & G. S. Rpt., 1881, App. 9. |
| 13.31 | | | | C. A. Schott. | Do. |
| 13.30 | | | | Do. | Do. |
| 13.37 | 74.15 | 3.540 | 12.96 | Do. | Do. |
| 13.49 | | | | H. W. Richardson. | Do. |
| 13.49 | | | | Do. | Do. |
| 13.47 | | | | Do. | Do. |
| 13.38 | | | | T. C. Hilgard. | Do. |
| 13.04 | 74.88 | 3.28 | 12.6 | C. A. Schott. | Do. |
| 13.57 | 74.48 | 3.522 | 13.16 | G. Davidson. | Do. |
| 13.12 | 74.10 | 3.508 | 12.80 | G. W. Dean and A. D. Bache. | Do. |
| 13.41 | 74.36 | 3.495 | 12.96 | C. A. Schott. | Do. |
| 13.40 | 74.37 | 3.483 | 12.93 | T. C. Hilgard. | Do. |
| 13.33 | 74.45 | 3.455 | 12.89 | C. A. Schott. | Do. |
| 13.30 | 75.09 | 3.330 | 12.94 | G. W. Dean. | Do. |
| 13.26 | 74.53 | 3.418 | 12.81 | C. A. Schott. | Do. |
| 13.79 | 74.72 | 3.543 | 13.44 | J. E. Hilgard and A. D. Bache. | Do. |
| 13.54 | 74.72 | 3.481 | 13.21 | G. W. Dean and R. J. Breckinridge. | Do. |
| 13.53 | | | | G. W. Dean and S. Harris. | Do. |
| 13.81 | 75.27 | 3.413 | 13.42 | S. Harris. | Do. |
| 13.60 | 75.16 | 3.388 | 13.23 | G. W. Dean. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MAINE—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Locke's Mill. | 44 24 | 70 44 | 1845 | June 15. | 75 50.7 | 3.304 |
| Belfast. | 44 26.0 | 69 00.8 | 1863 | July 8. | 75 38.1 | 3.330 |
| Bethel, C. R. Locke's house. | 44 27.5 | 70 51 | 1845 | June 10. | 75 51.0 | 3.308 |
| Waterville. | 44 33 | 69 45 | 1849 | June, July, Aug. | 75 59.4 | 3.243 |
| Howard. | 44 37.7 | 67 23.7 | 1859 | Aug. 3–13. | 75 21.6 | 3.458 |
| Mount Saunders. | 44 39.0 | 68 36.5 | 1856 | July 8–17; Sept. 12, 14. | 75 58.6 | 3.279 |
| Mount Harris. | 44 39.9 | 69 08.9 | 1855 | Sept. 3–11. | 76 14.1 | 3.240 |
| Bangor. | 44 48 | 68 47 | 1841 | July. | 76 11.6 | ---- |
| Bangor, Thomas Hill. | 44 48.2 | 68 46.9 | 1857 | Oct. 10–16. | 76 14.7 | 3.231 |
| Do. | 44 48.2 | 68 46.9 | 1863 | July 10. | 76 05.3 | 3.208 |
| Do. | 44 48.2 | 68 46.9 | 1879 | Aug. 21. | 75 29.8 | 3.317 |
| Humpback. | 44 51.8 | 68 06.6 | 1858 | Aug. 24–Sept. 15. | 76 12.0 | 3.220 |
| Eastport, Fort Sullivan. | 44 54.4 | 66 59.2 | 1860 | Jan. to Dec. | 75 53.1 | 3.307 |
| Do. | 44 54.4 | 66 59.2 | 1861 | Jan. to Dec. | 75 51.0 | 3.307 |
| Do. | 44 54.4 | 66 59.2 | 1862 | Jan. to Dec. | 75 48.5 | 3.303 |
| Do. | 44 54.4 | 66 59.2 | 1863 | Jan. to Dec. | 75 48.3 | 3.310 |
| Do. | 44 54.4 | 66 59.2 | 1864 | Jan. to July. | 75 45.8 | 3.313 |
| Do. | 44 54.4 | 66 59.2 | 1865 | July 22–25. | 75 44.7 | 3.317 |
| Eastport. | 44 54.3 | 66 59.3 | 1873 | Aug. 28–Sept. 4. | 75 24.3 | 3.363 |
| Do. | 44 54.4 | 66 59.2 | 1879 | Aug. 27, 28. | 75 12.2 | 3.404 |
| Cooper. | 44 59.2 | 67 28.0 | 1859 | Sept. 10–15. | 76 20.3 | 3.180 |
| Calais. | 45 11.0 | 67 16.8 | 1857 | Sept. 18–23. | 76 25.5 | 3.231 |
| Forks of Kennebec. | 45 20 | 69 58 | 1844 | Aug. | 76 23.7 | ---- |
| Moose River. | 45 39 | 70 16 | 1844 | Aug. | 76 48.5 | ---- |
| Tachereau's. | 45 49 | 70 24 | 1844 | ---- | 76 50.4 | ---- |
| Source of Saint Croix, N. E. boundary station. | 45 57.4 | 67 46.8 | 1840 | Oct. | 76 57.4 | ---- |
| Park's Hill. | 46 07 | 67 47 | 1840 | Nov. | 77 02.5 | ---- |
| Do. | 46 07 | 67 47 | 1841 | Aug. | 77 00.7 | ---- |
| Branch of the Saint John. | 46 25 | 70 04 | 1844 | ---- | 77 24.8 | ---- |
| River Saint John, near the Grand Forks. | 46 35 | 69 53 | 1843 | ---- | 77 25.9 | ---- |
| Blue Hill. | 46 38 | 67 47 | 1841 | ---- | 77 18.1 | ---- |
| Aroostook. | 46 47 | 67 47 | 1841 | ---- | 77 24.1 | ---- |
| Big Black River, mouth of Chim-passa-ooe-tuc. | 46 57 | 69 27 | 1843 | ---- | 77 37.5 | ---- |
| Peconk Hill. | 46 59 | 67 47 | 1841 | ---- | 77 32.2 | ---- |
| Falls of Saint John. | 47 03 | 67 45 | 1843 | ---- | 77 29.5 | ---- |
| River Saint John, north bank. | 47 04 | 67 47 | 1843 | ---- | 77 31.0 | ---- |

*intensities in the United States and adjacent regions.—Continued.*

MAINE—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| 13.52 | 74.97 | 3.370 | 13.00 | J. Locke. | Phil. Trans. R. S., 1846; Smithsonian Cont's to Know., Vol. III, 1852. |
| 13.42 | 74.66 | 3.430 | 12.97 | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.54 | 74.97 | 3.374 | 13.01 | J. Locke. | Phil. Trans. R. S., 1846; Smithsonian Cont's to Know., Vol. III, 1852. |
| 13.40 | 75.08 | 3.341 | 12.98 | G. W. Keely. | C. & G. S. Rpt., 1881, App. 9. |
| 13.68 | 74.36 | 3.580 | 13.28 | G. W. Dean and A. D. Bache. | Do. |
| 13.53 | 75.00 | 3.412 | 13.18 | G. W. Dean and J. H. Toomer. | Do. |
| 13.62 | 75.25 | 3.376 | 13.26 | G. W. Dean and T. M. McIver. | Do. |
| ---- | | | | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| 13.59 | 75.07 | 3.335 | 12.95 | G. W. Dean, S. Harris, and H. W. Bache. | C. & G. S. Rpt., 1881, App. 9. |
| 13.34 | | | | C. A. Schott. | Do. |
| 13.24 | | | | J. B. Baylor. | Do. |
| 13.50 | 75.21 | 3.346 | 13.11 | G. W. Dean, A. T. Mosman, and A. D. Bache. | Do. |
| 13.56 | | | | G. B. Vose. | Do. |
| 13.53 | | | | G. B. Vose and S. Walker. | Do. |
| 13.47 | | | | S. Walker, R. H. Talcott, and E. Goodfellow. | Do. |
| 13.50 | | | | E. Goodfellow. | Do. |
| 13.48 | 74.73 | 3.413 | 12.96 | E. Goodfellow, A. T. Mosman, and H. W. Richardson. | Do. |
| 13.47 | | | | H. W. Richardson. | Do. |
| 13.35 | | | | T. C. Hilgard. | Do. |
| 13.33 | | | | J. B. Baylor. | Do. |
| 13.46 | 75.34 | 3.302 | 13.05 | G. W. Dean and A. D. Bache. | Do. |
| 13.76 | 75.43 | 3.361 | 13.36 | G. W. Dean and S. Harris. | Do. |
| ---- | 75.53 | ---- | ---- | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| ---- | 75.94 | ---- | ---- | Do. | Do. |
| ---- | 75.97 | ---- | ---- | Do. | Do. |
| ---- | 76.10 | ---- | ---- | Do. | Sill. J., Vol. IV, 1847; Am. Phil. Soc., Vol. IX, 1846. |
| ---- | 76.16 | ---- | ---- | Do. | Sill. J., Vol. IV, 1847. |
| ---- | | | | | Phil. Trans. R. S., 1846. |
| ---- | 76.54 | ---- | ---- | Do. | Sill. J., Vol. IV, 1847. |
| ---- | 76.56 | ---- | ---- | Do. | Do. |
| ---- | 76.44 | ---- | ---- | Do. | Do. |
| ---- | 76.54 | ---- | ---- | Do. | Do. |
| ---- | 76.75 | ---- | ---- | Do. | Do. |
| ---- | | | | | |
| ---- | 76.65 | ---- | ---- | Do. | Do. |
| ---- | | | | | |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MAINE—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | | |
| Little Black River, mouth of Passa-ooe-tuc. | 47 07 | 69 05 | 1844 | ---- | 77 40.5 | ---- |
| Saint Francis River. | 47 11 | 68 54 | 1843 | ---- | 77 43.5 | ---- |
| Grand River, mouth. | 47 11 | 67 57 | 1844 | ---- | 77 38.4 | ---- |
| Do. | 47 11 | 67 57 | 1847 | ---- | 77 36 | ---- |
| Fort Kent, Fish River. | 47 15 | 68 35 | 1843 | ---- | 77 43.1 | ---- |
| Albert's Inn, River Saint John. | 47 17 | 68 27 | 1843 | ---- | 77 44.5 | ---- |
| Beau Lac, head. | 47 22 | 69 03 | 1843 | ---- | 77 47 | ---- |
| Madawaska River, mouth. | 47 22 | 68 19 | 1843 | ---- | 77 47.5 | ---- |
| Do. | 47 22 | 68 19 | 1847 | ---- | 77 45 | ---- |
| Lake Pohenagamook, outlet. | 47 28 | 69 13 | 1843 | ---- | 77 49.2 | ---- |

MARYLAND.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Mason's Landing. | 38 13.8 | 75 15.0 | 1856 | Aug. 30. | 70 44.8 | 4.406 |
| Davis. | 38 20.4 | 75 06.4 | 1853 | Sept. 21–25. | 70 57.7 | 4.332 |
| Calvert. | 38 21.5 | 76 23.6 | 1871 | July 31; Aug. 4. | 70 33.9 | 4.485 |
| Oxford. | 38 41.4 | 76 10.5 | 1856 | Aug. 23. | 70 58.0 | 4.384 |
| Marriott. | 38 52.4 | 76 36.6 | 1846 | May 27; June 2, 4. | 71 10.9 | 4.260 |
| Do. | 38 52.4 | 76 36.6 | 1849 | June 1–16. | 71 12.9 | 4.332 |
| Hill. | 38 53.9 | 76 52.8 | 1850 | Sept. 18–27. | 71 12.2 | 4.317 |
| Do. | 38 53.9 | 76 52.8 | 1868 | Oct. 27, 28, 29. | 71 17.1 | 4.378 |
| South base, Kent Island. | 38 53.9 | 76 22.0 | 1845 | June 3, 4. | 71 37.0 | 4.206 |
| Taylor. | 38 59.8 | 76 28.0 | 1845 | May 31; June 1. | 71 40.2 | 4.231 |
| Do. | 38 59.8 | 76 28.0 | 1847 | May 28; June 1, 5. | 71 19.3 | 4.222 |
| Kent Island, station 1. | 39 01.8 | 76 19.1 | 1849 | June 27–July 9. | 71 16.6 | 4.307 |
| Soper. | 39 05.2 | 76 57.0 | 1850 | July 22–25. | 71 56.5 | 4.144 |
| Webb. | 39 05.3 | 76 40.5 | 1850 | Nov. 20–27. | 71 24.0 | 4.280 |
| Do. | 39 05.3 | 76 40.5 | 1868 | Sept. 23–28. | 71 18.5 | 4.337 |
| Stabler. | 39 07.2 | 76 59.1 | 1869 | Aug. 24–28. | 71 28.1 | 4.287 |
| Bodkin Light. | 39 08.0 | 76 25.5 | 1847 | Apr. 25, 26. | 71 43.1 | 4.189 |
| North Point. | 39 11.7 | 76 26.7 | 1846 | July 7, 8. | 71 29.5 | 4.183 |
| Pool's Island. | 39 17.1 | 76 15.8 | 1847 | June 23; July 1. | 71 52.1 | 4.117 |
| Baltimore, near Washington Monument. | 39 17.8 | 76 36.9 | 1832 | July. | ---- | 4.228 |
| Baltimore, Saint Mary's College. | 39 17.5 | 76 37.5 | 1834 | July. | 70 58.6(?) | ---- |
| Baltimore, grove in Howard's Wood. | 39 18 | 76 36.6 | 1839 | Sept. | 71 50.3 | ---- |
| Do. | 39 17.8 | 76 36.6 | 1840 | Aug. | 71 34.1 | 4.265 |
| Baltimore, Saint Mary's College and near Washington Monument. | { 39 17.5<br>39 17.8 | 76 37.5<br>76 36.9 | } 1841 | Apr. 28. | { 71 34.1<br>71 39.2 | 4.266<br>4.243 |
| Baltimore, northeast of Washington Monument and at Saint Mary's College. | 39 17.8 | 76 37 | 1841 | Apr. to Sept. | 71 43.4 | ---- |

*intensities in the United States and adjacent regions.—Continued.*

MAINE—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| ---- | ° 76. 81 | ---- | ---- | J. D. Graham. | Sill. J., Vol. IV., 1847. |
| ---- | 76. 85 | ---- | ---- | Do. | Do. |
| ---- | 76. 74 | ---- | ---- | Do. | Do. |
| ---- | | | | G. W. Keely. | Phil. Trans. R. S., 1872. |
| ---- | 76. 85 | ---- | ---- | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| ---- | 76. 87 | ---- | ---- | Do. | Do. |
| ---- | 76. 91 | ---- | ---- | Do. | Do. |
| ---- | 76. 89 | ---- | ---- | Do. | Do. |
| ---- | | | | G. W. Keely. | Phil. Trans. R. S., 1872. |
| ---- | 76. 95 | ---- | ---- | J. D. Graham. | Sill. J., Vol. IV, 1847. |

MARYLAND.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 13. 36 | 70. 15 | 4. 491 | 13. 23 | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13. 28 | 70. 39 | 4. 415 | 13. 16 | J. E. Hilgard. | Do. |
| 13. 48 | 70. 05 | 4. 539 | 13. 30 | A. T. Mosman. | Do. |
| 13. 44 | 70. 37 | 4. 494 | 13. 38 | C. A. Schott. | Do. |
| 13. 21 | 70. 68 | 4. 366 | 13. 20 | T. J. Lee. | Do. |
| 13. 45 | | | | A. D. Bache and J. Hewston. | Do. |
| 13. 40 | 70. 69 | 4. 418 | 13. 36 | G. W. Dean and A. D. Bache. | Do. |
| 13. 64 | | | | C. O. Boutelle. | Do. |
| 13. 34 | 71. 11 | 4. 268 | 13. 18 | T. J. Lee. | Do. |
| 13. 45 | 70. 97 | 4. 292 | 13. 16 | Do. | Do. |
| 13. 18 | | | | Do. | Do. |
| 13. 42 | 70. 75 | 4. 381 | 13. 29 | J. Hewston. | Do. |
| 13. 37 | 71. 40 | 4. 221 | 13. 23 | G. W. Dean and A. D. Bache. | Do. |
| 13. 42 | 70. 81 | 4. 379 | 13. 32 | Do. | Do. |
| 13. 53 | | | | C. O. Boutelle. | Do. |
| 13. 49 | 70. 93 | 4. 348 | 13. 31 | Do. | Do. |
| 13. 35 | 71. 10 | 4. 252 | 13. 13 | T. J. Lee. | Do. |
| 13. 18 | | | | Do. | Do. |
| 13. 23 | 71. 36 | 4. 185 | 13. 09 | Do. | Do. |
| ---- | | | | J. N. Nicollet. | C. S. Rpt., 1864, App. 19. |
| ---- | | | | E. H. Courtenay and A. D. Bache. | Am. Phil. Soc., Vol. V, 1835; Sill. J., Vol. XXXIV, 1838, E. Loomis. Supposed misprint for 71° 58′.6. |
| ---- | | | | E. Loomis. | Sill. J., Vol. XXXIX, 1840. |
| 13. 49 | | | | A. D. Bache. | C. S. Rpt., 1862; Trans. R. S., 1846. |
| 13. 49 | | | | J. Locke. | Sill. J., Vol. IV., 1847; Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13. 48 | | | | | |
| ---- | | | | J. D. Graham. | Phil. Trans. R. S., 1846. θ mean of five determinations. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MARYLAND—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | | |
| Baltimore, northeast of Washington Monument and at Saint Mary's College. | 39 17.8 | 76 37 | 1841 | Apr. to Nov. | 71 41.5 | ---- |
| Baltimore, northeast of Washington Monument, in grove. | 39 18 | 76 36.6 | 1842 | --- | 71 39.7 | ---- |
| Baltimore, Howard's Wood and garden of Saint Mary's College. | 39 17.8 | 76 37 | 1842 | Oct. 8. | 71 43.3 | 4.234 |
| Do. | 39 17.8 | 76 37 | 1844 | July. | 71 36.0 | ---- |
| Baltimore, Fort McHenry. | 39 15.9 | 76 34.9 | 1856 | Sept. 13. | 71 45.8 | 4.203 |
| Do. | 39 15.9 | 76 34.9 | 1877 | Oct. 13. | 71 36.5 | 4.246 |
| Rosanne. | 39 17.5 | 76 43.1 | 1845 | June 10, 11. | 72 06.6 | 4.053 |
| Maryland Heights. | 39 20.4 | 77 43.0 | 1870 | Oct. 17–Nov. 6. | 71 28.0 | 4.324 |
| Finlay. | 39 24.4 | 76 31.5 | 1845 | June 13, 14. | 71 52.9 | 4.059 |
| Do. | 39 24.4 | 76 31.5 | 1846 | Apr. 10–16. | 71 47.9 | 4.113 |
| Osborne's Ruin. | 39 27.9 | 76 16.9 | 1845 | June 25, 30; July 2, 3. | 71 47.6 | 4.143 |
| Susquehanna Light. | 39 32.4 | 76 05.1 | 1847 | July 6, 7, 8. | 71 52.1 | 4.086 |
| Frenchtown. | 39 35 | 75 51 | 1840 | Aug. | 71 40.2 | 4.312 |
| Cumberland. | 39 39 | 78 44 | 1844 | Mar. 26. | 71 36.0 | 4.265 |
| Frostburgh. | 39 41 | 78 56 | 1840 | Aug. | 71 31.3 | 4.298 |
| Emmittsburgh, Mount Saint Mary's College. | 39 41 | 77 18 | 1842 | Apr. 12. | 71 46.3 | 4.244 |

MASSACHUSETTS.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Nantucket. | 41 17.0 | 70 06.0 | 1843 | Sept. | 73 41.2 | ---- |
| Nantucket, on North Beach. | 41 17.5 | 70 06.0 | 1846 | July 29; Aug. 2. | 73 44.4 | 3.653 |
| Nantucket, on beach west of light-house. | 41 17.5 | 70 06.0 | 1855 | Aug. 22. | 74 00.6 | 3.626 |
| Nantucket, cliff station. | 41 17.2 | 70 06.3 | 1867 | May 28; June 5. | 73 37.6 | 3.749 |
| Nantucket, bluff. | 41 17.3 | 70 06.3 | 1875 | Sept. 15–17. | 73 24.1 | 3.817 |
| Nantucket, cliff. | 41 17.2 | 70 06.3 | 1879 | July 31; Aug. 2. | 73 15.1 | 3.799 |
| Sampson's Hill. | 41 22.7 | 70 29.0 | 1846 | July 22; Aug. 15. | 73 24.5 | 3.753 |
| Indian, near station. | 41 25.7 | 70 40.6 | 1845 | July 30; Aug. 4, 5 | 73 41.4 | 3.734 |
| Indian. | 41 25.7 | 70 40.7 | 1846 | Aug. 11, 12, 13. | 73 29.1 | 3.728 |
| Vineyard Haven. | 41 27.9 | 70 35.5 | 1875 | Sept. 21, 22. | 73 09.9 | 3.893 |
| Tarpaulin Cove. | 41 28.1 | 70 45.4 | 1846 | Aug. 7, 8. | 73 49.8 | 3.696 |
| Fairhaven. | 41 37.4 | 70 54.1 | 1845 | Oct. 16, 17. | 74 40.0 | 3.592 |
| Hyannis. | 41 37.9 | 70 18.4 | 1846 | Aug. 22–25. | 73 49.2 | 3.682 |
| Chatham. | 41 40.2 | 69 56.9 | 1860 | Sept. 10, 11. | 73 46.2 | 3.744 |
| Shootflying. | 41 41.1 | 70 20.8 | 1845 | Aug. 25; Sept. 2. | 74 23.3 | 3.657 |
| Do. | 41 41.1 | 70 20.8 | 1846 | Aug. 28, 29, 30. | 73 56.5 | 3.663 |
| Copecut. | 41 43.3 | 71 03.6 | 1844 | Oct. 3, 4. | 74 09.5 | ---- |
| Manomet. | 41 55.6 | 70 35.5 | 1845 | Sept. 12. | 74 30.0 | 3.640 |
| Do. | 41 55.6 | 70 35.5 | 1846 | Sept. 1. | 74 01.2 | ---- |
| Do. | 41 55.6 | 70 35.5 | 1867 | Aug. 7–22. | 73 58.5 | 3.760 |

*intensities in the United States and adjacent regions.—Continued.*

MARYLAND—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| ---- | ° 71.16 | 4.291 | 13.29 | J. N. Nicollet. | Am. Phil. Soc., Vol. VIII, 1843. θ mean of four determinations. |
| ---- | | | | J. D. Graham. | Phil. Trans. R. S., 1846. |
| 13.499 | | | | J. H. Lefroy. | Diary Mag. Sur. Canada, Gen'l Sir J. H. Lefroy, London, 1883. |
| ---- | | | | J. D. Graham. | Phil. Trans. R. S., 1846. θ mean of two determinations. |
| 13.43 | | | | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.46 | | | | J. B. Baylor. | Do. |
| 13.19 | 71.60 | 4.115 | 13.04 | T. J. Lee. | Do. |
| 13.60 | 70.94 | 4.382 | 13.42 | C. O. Boutelle. | Do. |
| 13.05 | 71.33 | 4.150 | 12.96 | T. J. Lee. | Do. |
| 13.17 | | | | T. J. Lee and J. Locke. | Do. |
| 13.26 | 71.28 | 4.205 | 13.10 | T. J. Lee. | Do. |
| 13.13 | 71.36 | 4.154 | 13.00 | Do. | Do. |
| ---- | 71.15 | 4.354 | 13.48 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.51 | 71.09 | 4.323 | 13.34 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | 71.00 | 4.340 | 13.33 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.57 | 71.26 | 4.294 | 13.37 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |

MASSACHUSETTS.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| ---- | | | | W Mitchell. | Sill. J., Vol. XLVI. |
| 13.04 | | | | T. J. Lee. | C. & G. S. Rpt., 1881, App. 9. |
| 13.16 | 72.81 | 3.815 | 12.91 | C. A. Schott. | Do. |
| 13.30 | | | | C. O. Boutelle. | Do. |
| 13.36 | | | | J. M. Poole. | Do. |
| 13.18 | | | | J. B. Baylor. | Do. |
| 13.14 | 72.53 | 3.827 | 12.75 | T. J. Lee. | Do. |
| 13.29 | 72.71 | 3.801 | 12.79 | Do. | Do. |
| 13.12 | | | | Do. | Do. |
| 13.44 | 72.47 | 3.928 | 13.04 | J. M. Poole. | Do. |
| 13.27 | 72.94 | 3.770 | 12.85 | T. J. Lee. | Do. |
| 13.58 | 73.79 | 3.660 | 13.11 | Do. | Do. |
| 13.21 | 72.93 | 3.756 | 12.80 | T. J. Lee and R. H. Fauntleroy. | Do. |
| 13.39 | 72.77 | 3.861 | 13.04 | C. A. Schott. | Do. |
| 13.59 | 73.28 | 3.730 | 12.97 | T. J. Lee. | Do. |
| 13.24 | | | | T. J. Lee and R. H. Fauntleroy. | Do. |
| ---- | 73.29 | ---- | ---- | T. J. Lee. | Do. |
| 13.62 | | | | Do. | Do. |
| ---- | 73.26 | 3.772 | 13.10 | R. H. Fauntleroy. | Do. |
| 13.62 | | | | C. O. Boutelle. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MASSACHUSETTS—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Wellfleet. | 41 56.1 | 70 01.8 | 1860 | Sept. 12, 13. | 74 20.2 | 3.638 |
| Plymouth. | 41 58 | 70 39 | 1876 | July 11, 12. | 73 48.3 | 3.745 |
| Longmeadow, west of village church. | 42 02 | 72 36 | 1839 | Sept. | 74 05.3 | ---- |
| Provincetown. | 42 03.2 | 70 11.1 | 1860 | Sept. 14, 15. | 74 09.7 | 3.656 |
| Springfield. | 42 06 | 72 36 | 1834 | Aug. | 74 11 | ---- |
| Do. | 42 06 | 72 36 | 1834 | Aug. | 74 10.7 | ---- |
| Springfield, rear of Pinchyn House. | 42 06 | 72 36 | 1835 | ---- | ---- | 3.721 |
| Springfield, east of Hampton coffee-house. | 42 06 | 72 36 | 1839 | Sept. | 74 06.9 | ---- |
| Springfield. | 42 06 | 72 36 | 1841 | ---- | 74 10.7 | ---- |
| Springfield, in yard west of American Hotel. | 42 01 | 72 36 | 1843 | March 25. | 73 39 7 | ---- |
| Springfield, near Chestnut and East Worthington streets. | 42 06 | 72 32 | 1859 | July 26. | 74 14.9 | 3.691 |
| Blue Hill. | 42 12.7 | 71 06.9 | 1845 | Sept. 29–Oct. 8. | 75 05.6 | 3.519 |
| Easthampton. | 42 15 | 72 40 | 1862 | July 7–11. | 74 06.1 | 3.691 |
| Worcester, west of Worcester House. | 42 16 | 71 48 | 1839 | Sept. | 74 20.6 | ---- |
| Nantasket. | 42 18.2 | 70 54.3 | 1847 | Sept. 1, 2, 3. | 74 15.9 | 3.566 |
| Dorchester, South Boston Heights. | 42 19 | 71 04 | 1839 | ---- | 74 19 | ---- |
| Do. | 42 19 | 71 04 | 1839 | Sept. | 74 16.0 | 3.658 |
| Boston. | 42 21 | 71 04 | 1841 | July. | 74 09.4 | ---- |
| Do. | 42 20 | 71 04 | 1842 | May 2. | 74 05.7 | 3.669 |
| Dorchester, South Boston, near Grove Hill. | 42 19 | 71 03 | 1842 | Oct. 1. | 74 12.8 | ---- |
| Dorchester, South Boston Heights. | 42 20 | 71 02.6 | 1846 | Sept. 3–7. | 74 12.7 | 3.587 |
| Dorchester, South Boston Heights, near Blind Asylum. | 42 20 | 71 02.6 | 1855 | Aug. 24. | 74 29.5 | 3.544 |
| Do. | 42 20 | 71 02.4 | 1872 | Sept., Oct. | 73 31 (?) | 3.675 |
| Cambridge. | 42 23 | 71 07 | 1780 | Dec. 25. | 69 51 | ---- |
| Do. | 42 23 | 71 07 | 1782 | June 2. | 69 41 | ---- |
| Do. | 42 23 | 71 07 | 1783 | Dec. 23. | 69 41 | ---- |
| Cambridge, southwest of colleges. | 42 22.5 | 71 07.5 | 1839 | Sept. | 74 20.1 | ---- |
| Cambridge, Harvard College Observatory. | 42 23 | 71 08 | 1840 | ---- | 74 21.6 | ---- |
| Do. | 42 22.9 | 71 07.7 | 1841 | June. | 74 17.3 | ---- |
| Cambridge, grounds of Observatory. | 42 22.9 | 71 07.7 | 1842 | ---- | 74 19.5 | 3.665 |
| Cambridge. | 42 23 | 71 08 | 1842 | ---- | 74 17.8 | ---- |
| Do. | 42 23 | 71 08 | 1842 | May 4. | 74 14.9 | 3.661 |
| Cambridge, new Observatory. | 42 22.9 | 71 07.7 | 1844 | Dec. | 74 18.2 | ---- |
| Cambridge, Observatory grounds. | 42 23 | 71 08 | 1845 | June 2. | 74 19.4 | 3.618 |
| Cambridge, Harvard College Observatory. | 42 22.9 | 71 07.7 | 1850 | Aug. 9. | 74 34 | ---- |

*intensities in the United States and adjacent regions.—Continued.*

MASSACHUSETTS—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| 13.48 | 73.34 | 3.755 | 13.10 | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 73.16 | 3.777 | 13.04 | F. E. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected by C. A. S.] |
| ---- | 73.23 | ---- | ---- | E. Loomis. | Sill. J., 1840. |
| 13.40 | 73.16 | 3.773 | 13.02 | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | A. D. Bache. | Sill, J., 1838, E. Loomis. |
| ---- | | | | Do. | Sill. J., Vol. XXXIV, 1838, E. Loomis. |
| 13.65 | | | | A. D. Bache and E. H. Courtenay. | Am. Phil. Soc., Vol. V, 1837; C. S. Rpt., 1851, App. 22. H. at Phila.=4.195, used as unit (Schott). |
| ---- | 73.20 | 3.772 | 13.05 | E. Loomis. | Sill, J., 1840. |
| ---- | | | | A. D. Bache. | Phil. Trans. R. S., 1846. |
| 13.379 | | | | J. H. Lefroy. | Diary Mag. Sur., Canada, Genl. Sir J. H. Lefroy, London, 1883. |
| 13.60 | | | | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.68 | 74.22 | 3.585 | 13.18 | T. J. Lee. | Do. |
| 13.47 | 73.11 | 3.797 | 13.07 | E. Goodfellow and A. D. Bache. | Do. |
| ---- | 73.48 | ---- | ---- | E. Loomis. | Sill. J., 1840. |
| 13.15 | 73.37 | 3.648 | 12.75 | T. J. Lee. | Do. |
| ---- | | | | W. C. Bond. | Do. |
| 13.39 | | | | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | | | | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| 13.40 | | | | J. Locke. | Do. |
| 13.327 | 73.21 | 3.695 | 12.79 | J. H. Lefroy. | Diary Mag. Sur., Canada, Genl. Sir J. H. Lefroy, London, 1883. |
| 13.18 | | | | T. J. Lee and R. H. Fauntleroy. | C. & G. S. Rpt., 1881, App. 9. |
| 13.26 | | | | C. A. Schott. | Do. |
| 12.95 (?) | | | | A. H. Scott and E. Goodfellow. | Do. |
| ---- | | | | Williams. | Sill. J., Vol. XXXIV, 1838, E. Loomis. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | | | | Do. | Do. |
| ---- | | | | E. Loomis. | Sill. J., Vol. XXXIX, 1840. |
| ---- | | | | J. Lovering and W. Bond. | Mem. Am. Acad., Vol. II, 1846. |
| ---- | | | | J. D. Graham & W. C. Bond. | Phil. Trans. R. S., 1846, Tab. LI, E. Sabine. |
| 13.458 | | | | J. H. Lefroy. | Diary Mag. Sur., Canada, Genl. Sir J. H. Lefroy, London, 1883.<br>Phil. Trans. R. S., 1846. θ, H & F., obs'd. |
| ---- | | | | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| 13.49 | | | | J. Locke. | Sill. J., Vol. IV, 1847; Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | 73.28 | 3.704 | 12.88 | J. D. Graham. | Phil. Trans. R. S., 1846, Tab. LI. E. Sabine. |
| 13.39 | | | | J. Locke. | C. S. Rpt., 1861, App. 22. |
| ---- | | | | J. C. Ives and A. W. Whipple. | C. S. Rpt., 1856, p. 222. |

TABLE I.—*Observed magnetic dips and horizontal and total*

MASSACHUSETTS—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Cambridge, Harvard College Observatory. | 42 22.9 | 71 07.7 | 1854 | May 10. | 74 33 | ---- |
| Do. | 42 23 | 71 08 | 1856 | July 19. | 74 12 | 3.542 |
| Do. | 42 22.9 | 71 07.7 | 1859 | Mar. 7. | 74 20 | 3.596 |
| Cambridge, grounds of Harvard College Observatory. | 42 22.8 | 71 07.6 | 1879 | Aug. 7–9. | 73 48.4 | 3.707 |
| Chesterfield. | 42 24 | 72 51 | 1859 | July 25. | 74 21.2 | 3.667 |
| Little Nahant. | 42 26.2 | 70 55.8 | 1849 | Aug. 13–17. | 74 29.5 | 3.556 |
| Wachusett. | 42 29.2 | 71 53.2 | 1860 | Sept. 27–Oct. 10. | 74 28.8 | 3.633 |
| Fort Lee, Salem. | 42 31.9 | 70 52.5 | 1849 | Aug. 18. | ---- | 3.487 |
| Do. | 42 31.9 | 70 52.5 | 1855 | Aug. 25. | 75 36.9 | 3.489 |
| Baker's Island Light. | 42 32.2 | 70 47.2 | 1849 | Aug. 31–Sept. 3. | 74 18.6 | 3.682 |
| Deerfield. | 42 33 | 72 36 | 1859 | July 23. | 74 35.3 | 3.617 |
| Fitchburg. | 42 35 | 71 48 | 1876 | July 22. | 74 09.8 | 3.694 |
| Greenfield. | 42 35 | 72 35 | 1876 | July 25, 26. | 74 06.1 | 3.702 |
| Beaconhill, Gloucester. | 42 36.2 | 70 38.6 | 1849 | Aug. 21, 25. | 74 26.4 | 3.617 |
| Do. | 42 36.2 | 70 38.6 | 1859 | July 8. | 74 45.6 | 3.645 |
| Thompson. | 42 36.7 | 70 43.8 | 1859 | July 9. | 74 30.4 | 3.674 |
| Lowell. | 42 39 | 71 20 | 1876 | July 19, 20. | 74 19.3 | 3.635 |
| Annisquam. | 42 39.4 | 70 40.6 | 1859 | July 11. | 74 56.1 | 3.589 |
| Rockport. | 42 39.6 | 70 36.6 | 1859 | July 11. | 75 05.9 | 3.529 |
| Ipswich. | 42 40.8 | 70 50.1 | 1859 | July 12. | 74 37.3 | 3.598 |
| North Adams. | 42 42 | 73 07 | 1876 | July 28, 29. | 74 15.3 | 3.709 |
| Plum Island, near Newburyport. | 42 48.0 | 70 48.8 | 1850 | Sept. 18, 19. | 74 54.9 | 3.530 |
| Do. | 42 48.0 | 70 48.8 | 1859 | July 13. | 74 52.9 | 3.528 |

MICHIGAN.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Monroe, southeast of village. | 41 55 | 83 27 | 1839 | May. | 73 32.3 | ---- |
| Monroe, one mile north of court-house. | 41 55 | 83 28 | 1841 | Aug. | 73 19.0 | ---- |
| Ypsilanti, hill east side of Huron River. | 42 14 | 83 37 | 1839 | May. | 73 18.0 | ---- |
| Ypsilanti, east of railroad depot. | 42 14 | 83 38 | 1841 | Aug. | 73 18.8 | ---- |
| Marshall, near astronomical post. | 42 16.4 | 84 57.8 | 1876 | Oct. 16, 17, 18. | 73 30.9 | 3.9233 |
| Ann Arbor, west of village. | 42 18 | 83 44 | 1839 | May. | 73 13.9 | ---- |
| Ann Arbor, south of railroad depot. | 42 18 | 83 45 | 1841 | Aug. | 73 16.5 | ---- |
| Ann Arbor. | 42 16.8 | 83 43.8 | 1843 | Aug. 13, 14. | 73 13.7 | 3.991 |
| Detroit. | 42 20 | 83 02 | 1839 | May. | 73 42.6 | ---- |
| Detroit, one mile west of the city. | 42 20 | 83 02 | 1841 | Aug. | 73 35.7 | ---- |
| Detroit, Judge Farnsworth's orchard, upper end of city. | 42 20 | 83 02 | 1841 | Sept. | 73 32.7 | ---- |
| Detroit, lane from wharf to Jefferson avenue. | 42 21 | 83 02 | 1842 | Nov. 4. | 73 28.7 | ---- |

*magnetic intensities in the United States and adjacent regions—Continued.*

MASSACHUSETTS—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| ---- | | | | J. C. Ives and A. W. Whipple. | C. S. Rpt., 1856, p. 222. |
| 13.006 | | | | K. Friesach. | K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858. Total force converted into Eng. units. |
| 13.318 | | | | W. P. Smith. | U. S. Lake Sur., Capt. G. G. Meade, 1859. |
| 13.29 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.60 | 73.35 | 3.789 | 13.22 | C. A. Schott. | Do. |
| 13.30 | 73.57 | 3.655 | 12.92 | G. W. Keely. | Do. |
| 13.58 | 73.48 | 3.750 | 13.19 | G. W. Dean, R. E. Halter, and A. D. Bache. | Do. |
| ---- | 74.63 | 3.606 | 13.61 | G. W. Keely. | Do. |
| 14.04 | | | | C. A. Schott. | Do. |
| 13.62 | 73.39 | 3.781 | 13.23 | G. W. Keely. | Do. |
| 13.61 | 73.59 | 3.739 | 13.23 | C. A. Schott. | Do. |
| ---- | 73.52 | 3.726 | 13.13 | F. E. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected by C. A. S.] |
| ---- | 73.46 | 3.734 | 13.12 | Do. | Do. |
| 13.48 | 73.64 | 3.741 | 13.28 | G. W. Keely. | C. & G. S. Rpt., 1881, App. 9. |
| 13.86 | | | | C. A. Schott. | Do. |
| 13.75 | 73.51 | 3.796 | 13.37 | Do. | Do. |
| ---- | 73.68 | 3.667 | 13.05 | F. E. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected by C. A. S.] |
| 13.81 | 73.93 | 3.711 | 13.41 | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.72 | 74.10 | 3.651 | 13.33 | Do. | Do. |
| 13.57 | 73.62 | 3.720 | 13.19 | Do. | Do. |
| ---- | 73.62 | 3.741 | 13.26 | F. E. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected by C. A. S.] |
| 13.56 | 73.93 | 3.645 | 13.17 | J. E. Hilgard. | C. & G. S. Rpt., 1881, App. 9. |
| 13.53 | | | | C. A. Schott. | Do. |

MICHIGAN.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| ---- | 72.91 | ---- | ---- | E. Loomis. | Sill. J., 1840. |
| ---- | | | | | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | 72.79 | ---- | ---- | Do. | Sill. J., 1840. |
| ---- | | | | | Am. Phil. Soc., Vol. VIII, 1843. |
| 13.826 | 73.13 | 3.956 | 13.63 | C. F. Powell. | U. S. Lake Sur., Rpt. 1877 & 1882. |
| ---- | 72.73 | 4.045 | 13.63 | E. Loomis. | Sill. J., 1840. |
| ---- | | | | Do. | Am. Phil. Soc., Vol. VIII, 1843. |
| 13.83 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844; Sill. J., Vol. IV, 1847. |
| ---- | | | | E. Loomis. | Sill. J., Vol. XXXIX., 1840. |
| ---- | | | | Do. | Am. Phil. Soc., Vol. VIII., 1843. |
| ---- | | | | J. N. Nicollet. | Do. |
| 13.820 | | | | C. Younghusband. | Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MICHIGAN—Continued.

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Detroit. | 42 21 | 83 02 | 1843 | June 12, 15. | 73 32.2 | 3.892 |
| Detroit, lane from wharf to Jefferson avenue. | 42 21 | 83 02 | 1845 | ---- | 73 38.8 | ---- |
| Detroit, Washington avenue, near Grand River avenue. | 42 20.0 | 83 02.5 | 1859 | Apr. | 73 41 | 3.838 |
| Do. | 42 20.0 | 83 02.5 | 1860 | May. | 73 43 | 3.865 |
| Detroit, in park near lake survey office. | 42 20.0 | 83 02.5 | 1872 | May 8–29. | 73 35 | 3.881 |
| Do. | 42 20.0 | 83 02.5 | 1873 | May 5–16. | 73 34 | 3.880 |
| Do. | 42 20.0 | 83 03.1 | 1876 | May, June. | 73 34.1 | 3.898 |
| Fort Gratiot, near astronomical station. | 42 59.9 | 82 25.0 | 1858 | Oct. 9. | 74 28 | 3.6890 |
| Fort Gratiot, near geodetic station. | 43 01 | 82 25 | 1860 | May 7. | 74 39 | 3.664 |
| Fort Gratiot, near old bake-house. | 42 59.9 | 82 25.0 | 1873 | July 15, 16. | 74 22 | 3.716 |
| Grand Haven, near Detroit and Milwaukee freight depot. | 43 05.2 | 86 12.6 | 1859 | Aug. 18. | 74 10 | 3.815 |
| Grand Haven, in rear of jail. | 43 05.0 | 86 12.6 | 1873 | Aug. 27, 28, 29. | 73 58 | 3.850 |
| Grand Haven. | 43 04.7 | 86 12.6 | 1880 | July 20, 21. | 73 53.7 | 3.847 |
| Wahley, on bluff near shore. | 43 22 | 82 32 | 1860 | May 11. | 74 41 | 3.670 |
| Saint Louis, near astronomical post. | 43 24.5 | 84 36.2 | 1876 | Oct. 14, 15. | 73 48.9 | 3.6432 |
| Saginaw, near astronomical post. | 43 25.1 | 83 57.8 | 1876 | Sept. 16–22. | 73 36.2 | 3.6718 |
| Forestville, near astronomical station. | 43 39.6 | 82 34.3 | 1858 | June and July. | 75 00 | 3.5246 |
| Forestville, near astronomical post. | 43 39.6 | 82 34.2 | 1873 | July 11, 12. | 74 54 | 3.636 |
| Sand Point, Saginaw Bay. | 43 54.7 | 83 23 | 1858 | Sept. 13–18. | 75 02 | 3.5718 |
| Sturgeon Point, near astronomical station. | 44 42.6 | 83 14.1 | 1858 | Sept. 25–29. | 75 59 | 3.3388 |
| South Manitou Island, middle of island. | 45 02 | 86 06 | 1841 | Aug. | 75 59.3 | ---- |
| South Manitou Island, 40 yards from wharf. | 45 02 | 86 06 | 1842 | Nov. 7. | 75 56.6 | ---- |
| South Manitou Island, east side, near dock. | 45 02 | 86 06 | 1860 | Sept. 11. | 76 01 | 3.360 |
| Thunder Bay Island, near astronomical station. | 45 02.2 | 83 09.1 | 1858 | Aug. 20–25. | 76 24 | 3.2411 |
| Northport, shore of Grand Traverse Bay. | 45 08 | 85 36 | 1860 | Sept. 2. | 76 06 | 3.340 |
| Cove Island, near light-house. | 45 20 | 81 43 | 1860 | Aug. 28. | 76 32 | 3.267 |
| Beaver Island, near light-house. | 45 45 | 85 30 | 1860 | Oct. 2. | 76 43 | 3.236 |
| Mackinac, ¼ mile southwest of fort. | 45 51 | 84 40 | 1841 | Aug. | 76 37.5 | ---- |
| Michillimackinac Island, ¼ mile southwest of new Fort Mackinac. | 45 51.5 | 84 38 | 1841 | Sept. | 76 34.2 | ---- |
| Michillimackinac Island, near old Fort Holmes. | 45 51.5 | 84 37.0 | 1841 | Sept. | 76 34.9 | ---- |
| Mackinac Island. | 45 51 | 84 39 | 1843 | June 18. | 76 38.8 | 3.257 |
| Mackinac Island, without the fort. | 45 51 | 84 36 | 1860 | July 28. | 76 43 | 3.242 |
| Mackinac, in rear of fort. | 45 51 | 84 38 | 1880 | July 28, 29. | 76 27.6 | 3.264 |
| Fort Brady, southeast of fort. | 46 29.9 | 84 20 | 1841 | Aug. | 77 29.7 | ---- |
| Sault de St. Marie. | 46 30 | 84 20 | 1843 | June. | 77 30.2 | 3.046 |
| Do. | 46 30 | 84 20 | 1856 | Sept. 29. | 77 44 | 3.0732 |
| Fort Brady, near Sault de St. Marie. | 46 30.1 | 84 20 | 1873 | July 22, 23. | 77 30 | 3.044 |
| Sault de St. Marie and Fort Brady. | 46 29.9 | 84 20.1 | 1880 | July 11, 13, 19. | ---- | 3.000 |
| Sault de St. Marie, garden of Fort Brady. | 46 29.9 | 84 20.1 | 1880 | Aug. 6, 7. | 77 24.0 | 3.056 |

*intensities in the United States and adjacent regions.—Continued.*

MICHIGAN—Continued.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| 13.73 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844; Sill. J., Vol. IV, 1847. |
| 13.72 | 73.09 | 3.934 | 13.53 | J. H. Lefroy. | Phil. Trans. R. S., 1846; Diary Mag. Sur. Can., Genl. Sir J. H. Lefroy, London, 1883. |
| 13.710 | | | | W. P. Smith. | U. S. Lake Sur. Rpt., 1859 & 1882. |
| 13.785 | | | | Do. | U. S. Lake Sur. Rpt., 1882. |
| 13.720 | | | | A. N. Lee. | U. S. Lake Sur. MS., 1873, & Rpt., 1882. |
| 13.715 | | | | Do. | Do. |
| 13.781 | | | | T. N. Bailey. | U. S. Lake Sur. Rpt., 1877, pt. 2, & 1882. |
| 13.798 | | | | W. P. Smith. | U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882. |
| 13.840 | 73.94 | 3.761 | 13.60 | Do. | U. S. Lake Sur. Rpt., 1882. |
| 13.790 | | | | A. N. Lee. | U. S. Lake Sur. MS., 1873, & Rpt., 1882. |
| 13.987 | | | | W. P. Smith. | U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882. |
| 13.940 | 73.58 | 3.886 | 13.75 | A. N. Lee. | U. S. Lake Sur. MS., 1873, & Rpt., 1882. |
| 13.87 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.893 | 74.08 | 3.754 | 13.69 | W. P. Smith. | U. S. Lake Sur. Rpt., 1882. |
| 13.070 | (73.44) | 3.677 | (12.90) | D. W. Lockwood. | U. S. Lake Sur. Rpt., 1877 & 1882. |
| 13.007 | (73.21) | 3.706 | (12.83) | Do. | Do. |
| 13.609 | 74.42 | 3.646 | 13.57 | W. P. Smith. | U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882. |
| 13.957 | | | | A. N. Lee. | U. S. Lake Sur. MS., 1873, & Rpt., 1882. |
| 13.835 | 74.43 | 3.657 | 13.62 | W. P. Smith. | U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882. |
| 13.786 | 75.38 | 3.424 | 13.57 | Do. | Do. |
| ---- | | | | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| 14.041 | 75.43 | 3.460 | 13.75 | C. Younghusband. | Diary Mag. Sur. Canada, Gen'l J. H. Lefroy, London, 1843. |
| 13.937 | | | | W. P. Smith. | U. S. Lake Sur. Rpt., 1882. |
| 13.792 | 75.80 | 3.326 | 13.56 | Do. | U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882. |
| 13.905 | 75.50 | 3.423 | 13.67 | Do. | U. S. Lake Sur. Rpt., 1882. |
| 14.063 | 75.93 | 3.350 | 13.78 | Do. | Do. |
| 14.084 | 76.12 | 3.319 | 13.84 | Do. | Do. |
| ---- | | | | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | | | | J. N. Nicollet. | Do. |
| ---- | 76.12 | 3.306 | 13.78 | Do. | Do. |
| 14.10 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 14.108 | | | | W. P. Smith. | U. S. Lake Sur. Rpt., 1882. |
| 13.94 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| 14.08 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 14.366 | 77.05 | 3.087 | 13.77 | K. Friesach. | K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858. |
| 14.064 | | | | A. N. Lee. | U. S. Lake Sur. MS., 1873, and Rpt., 1882. |
| ---- | | | | S. W. Very. | C. & G. S. Rpt., 1881, App. 9. |
| 14.01 | | | | J. B. Baylor. | Do. |

**TABLE I.—*Observed magnetic dips and horizontal and total magnetic***

MICHIGAN—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Marquette, ½ mile northwest of light-house. | 46 32.7 | 87 23.5 | 1859 | July 13. | 77 17 | 3.089 |
| Marquette, northwest of light-house. | 46 32.7 | 87 23.5 | 1873 | July 26, 28, 29. | 75 48 | 3.433 |
| Encampment, shore of Lake Superior. | 46 44 | 87 43 | 1843 | July 2. | 76 58.3 | 3.166 |
| Ontonagon. | 46 52 | 89 21 | 1843 | July 26. | 77 13.2 | 3.122 |
| Ontonagon, near light-house. | 46 52.2 | 89 20 | 1859 | July 19. | 77 27 | 3.064 |
| Ontonagon. | 46 52.2 | 89 20 | 1880 | Aug. 16, 17. | 77 16.6 | 3.094 |
| Eagle River. | 47 27 | 88 23 | 1843 | July 13. | 77 54.5 | 2.949 |
| Copper Harbor, near Eagle Harbor, Fort Wilkins. | 47 28.5 | 87 51.0 | 1859 | July 14. | 78 06 | 2.894 |
| Do. | 47 28.5 | 87 51.0 | 1873 | Aug. 1, 2, 3. | 78 02 | 2.928 |
| Houghton's River. | 47 28 | 88 01 | 1843 | July 8. | 77 20.7 | 3.054 |
| Magnetic Inlet. | 47 28.5 | 88 01 | 1843 | July 8, 11. | 78 44.3 | 2.821 |
| United States Agency. | 47 28 | 88 00 | 1843 | July 8. | 77 13.5 | 3.263 |
| Isthmus. | 47 28.5 | 88 00 | 1843 | July 11. | 78 28 | 2.866 |
| East of Magnetic Inlet, 500 feet. | 47 28.5 | 88 01 | 1843 | July 15. | 78 37.5 | 2.837 |
| Isle Royal. | 48 06 | 88 47 | 1843 | July 28. | 78 07.6 | 2.941 |
| **MINNESOTA.** | | | | | | |
| Heron Lake. | 43 47.6 | 95 24 | 1880 | Oct. 4, 5. | 73 31.2 | 3.924 |
| Wabasha, near Riverside house. | 44 18.0 | 92 07.0 | 1876 | Aug. 7, 8, 11, 12. | 74 21.6 | 3.724 |
| Red Wing, near astronomical post. | 44 33.7 | 92 32.0 | 1878 | Oct. 23–26. | 74 14.4 | 3.680 |
| Saint Peter, Fort Snelling. | 44 52 | 93 10 | 1836 | July. | 74 00 | 3.806 |
| Fort Snelling Reservation. | 44 53.5 | 93 11 | 1880 | Sept. 28, 29. | 74 55.6 | 3.619 |
| Saint Paul, near county court-house. | 44 56.7 | 93 05.4 | 1873 | Aug. 18, 19, 20. | 74 55 | 3.648 |
| Minneapolis. | 44 58.6 | 93 14.1 | 1877 | Sept. 28; Oct. 2. | 74 45.2 | 3.662 |
| Brainerd. | 46 21.0 | 94 15 | 1880 | Aug. 31; Sept. 1. | 75 42.5 | 3.422 |
| Minnesota Point, near south base. | 46 42.8 | 92 01.7 | 1871 | June 23. | 76 26 | 3.266 |
| Minnesota Point, near north base. | 46 45.4 | 92 04.5 | 1871 | June 16–25. | 76 21 | 3.319 |
| Duluth, southeast of Peck's house. | 46 45.5 | 92 04.5 | 1873 | Aug. 12, 13, 14. | 76 17 | 3.395 |
| Minnesota Point, near light-house. | 46 46.5 | 92 05 | 1859 | July 22. | 76 44 | 3.222 |
| Glyndon. | 46 52.4 | 96 40 | 1880 | Sept. 4, 6. | 75 48.2 | 3.415 |
| **MISSISSIPPI.** | | | | | | |
| East Pascagoula. | 30 20.7 | 88 32.8 | 1847 | June 22, 23. | ---- | 6.220 |
| Do. | 30 20.7 | 88 32.8 | 1848 | June 1, 4. | 60 27.2 | ---- |
| Do. | 30 20.7 | 88 32.9 | 1855 | Jan. 24; Feb. 3. | ---- | 6.250 |

*intensities in the United States and adjacent regions.—Continued.*

MICHIGAN—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| 14.034 | 76.00 | 3.326 | 13.75 | W. P. Smith. | U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882. |
| 13.991 | | | | A. N. Lee. | U. S. Lake Sur. MS., 1873, and Rpt., 1882. |
| 14.05 | 76.46 | 3.220 | 13.75 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 14.11 | | | | Do. | Do. |
| 14.100 | 76.87 | 3.145 | 13.84 | W. P. Smith. | U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882. |
| 14.05 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 14.08 | 77.39 | 3.003 | 13.76 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 14.033 | 77.56 | 2.976 | 13.83 | W. P. Smith. | U. S. Lake Sur., Capt. G. G. Meade, 1859, & Rpt., 1882. |
| 14.116 | | | | A. N. Lee. | U. S. Lake Sur. MS., 1873, & Rpt., 1882. |
| 13.94 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 14.45 | | | | Do. | Do. |
| 14.76 | 77.58 | 3.020 | 14.04 | Do. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. Dip disturbed. |
| 14.33 | | | | Do. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 14.39 | | | | Do. | Do. |
| 14.29 | 77.62 | 2.995 | 13.97 | Do. | Do. |

MINNESOTA.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 13.83 | 73.45 | 3.93 | 13.80 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.814 | 74.2 | 3.73 | 13.70 | T. N. Bailey. | U. S. Lake Sur. Rpt. Chief of Eng's, 1877, & Lake Sur. Rpt., 1882. |
| 13.547 | 74.1 | 3.69 | 13.47 | C. F. Powell. | U. S. Lake Sur. Rpt., 1879 & 1882. |
| ---- | 74.8 | 3.62 | 13.81 | J. N. Nicollet. | C. S. Rpt., 1864, App. 19. This station now called Mendota. |
| 13.92 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 14.018 | 74.8 | 3.65 | 13.92 | A. N. Lee. | U. S. Lake Sur. MS., 1873, & Rpt., 1882. |
| 13.92 | 74.6 | 3.67 | 13.82 | A. Braid. | C. & G. S. Rpt., 1881, App. 9. |
| 13.86 | 75.64 | 3.43 | 13.84 | J. B. Baylor. | Do. |
| 13.925 | | | | C. B. Comstock. | U. S. Lake Sur. MS., 1875, & Lake Sur. Rpt., 1882. |
| 14.065 | | | | Do. | Do. |
| 14.318 | 76.16 | 3.32 | 13.88 | A. N. Lee. | U. S. Lake Sur. MS., 1873, & Lake Sur. Rpt., 1882. |
| 14.038 | | | | W. P. Smith. | U. S. Lake Sur., G. G. Meade, Detroit, 1859, & Lake Sur. Rpt., 1882. |
| 13.92 | 75.73 | 3.42 | 13.88 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |

MISSISSIPPI.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 12.61 | | | | R. H. Fauntleroy and J. S. Ruth. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 60.4 | 6.25 | 12.65 | G. Davidson. | Do. |
| ---- | | | | J. E. Hilgard. | Do. |

**TABLE I.—*Observed magnetic dips and horizontal and total magnetic***

MISSISSIPPI—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Mississippi City. | 30 22.9 | 89 02.0 | 1855 | Mar. 27, 28. | ---- | 6.195 |
| Natchez, Chotard's residence. | 31 33.8 | 91 24.7 | 1834 | Mar., May. | 62 11 | 6.149 |
| Natchez, bluff north end of town. | 31 34 | 91 24 | 1872 | Apr. 22. | 61 26.7 | 5.874 |
| Jackson, rear of Free School. | 32 19 | 90 12 | 1872 | Apr. 28. | ---- | 5.665 |
| Vicksburg, Castle Hill, east of school-house. | 32 21 | 90 53 | 1872 | Apr. 24. | 62 28.4 | 5.749 |
| Grenada, northwest of town. | 33 47 | 89 50 | 1872 | Mar. 20. | 64 24.0 | 5.510 |
| Oxford, south of University grounds. | 34 22 | 89 32 | { 1871<br>1872 | Dec. 24.<br>May 3–9. } | 65 04.4 | 5.426 |
| Do. | 34 22 | 89 32 | 1872 | May 15. | 65 05.3 | 5.408 |
| Oxford University grounds. | 34 22 | 89 32 | 1879 | Dec. 1. | 65 08.8 | ---- |
| Corinth, between old forts. | 34 56 | 88 35 | 1871 | Dec. 3. | 65 54.6 | 5.248 |

MISSOURI.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Gatewood. | 36 31.8 | 91 03.0 | 1880 | July 13. | ---- | 5.022 |
| Doniphan. | 36 37.8 | 90 46.8 | 1880 | July 12. | ---- | 5.011 |
| Poplar Bluffs. | 36 44.4 | 90 21.6 | 1880 | July 10. | 67 14.0 | 5.026 |
| Charleston. | 36 55.8 | 89 19.2 | 1880 | July 8. | 67 47.0 | 4.948 |
| Howell Co. | 36 56.0 | 91 55.2 | 1880 | Aug. 3. | 67 37.1 | 4.940 |
| Piedmont. | 37 08.4 | 90 41.4 | 1880 | July 16. | 67 35.4 | 5.004 |
| Springfield. | 37 15.6 | 93 14.6 | 1879 | Aug. 29. | 67 12.6 | 5.115 |
| Houston. | 37 19.2 | 91 55.2 | 1880 | Aug. 1. | 67 16.4 | 5.030 |
| Lutesville. | 37 20.0 | 89 58.8 | 1880 | July 6. | 67 51.7 | 4.959 |
| Bolivar. | 37 35 | 93 24 | 1881 | Aug. 2. | 67 49.2 | 4.989 |
| Pilot Knob, base. | 37 37 | 90 37 | 1880 | July 19. | 69 59.2 | 4.590 |
| Pilot Knob, top. | 37 37 | 90 37 | 1880 | July 20. | ---- | 4.608 |
| Buffalo. | 37 37 | 93 06 | 1881 | Aug. 1. | 67 57.0 | 4.953 |
| Salem. | 37 39.0 | 91 30.6 | 1880 | July 29. | 68 01.8 | 4.952 |
| Lebanon. | 37 40.0 | 92 42.0 | 1879 | Aug. 30, 31. | 67 57.6 | 4.981 |
| Do. | 37 40.0 | 92 42.0 | 1881 | July 30. | ---- | 4.968 |
| Arcadia. | 37 46.2 | 90 40.8 | 1880 | July 17. | 68 33.9 | 4.889 |
| Wheatland. | 37 56 | 93 24 | 1881 | Aug. 5. | 68 16.6 | 4.855 |
| Schell City. | 38 02.6 | 94 04.6 | 1879 | Aug. 25. | 68 20.2 | 4.898 |
| Cuba. | 38 03.6 | 91 21.0 | 1880 | July 28. | 68 18.8 | 4.887 |
| Linn Creek. | 38 04 | 92 47 | 1881 | July 27. | 68 14.5 | 4.904 |
| De Soto. | 38 06.6 | 90 34.8 | 1880 | July 21. | 68 45.4 | 4.789 |
| Lawson's farm. | 38 11 | 92 11 | 1881 | July 20. | 68 20.6 | 4.927 |
| Vienna. | 38 12 | 91 54 | 1881 | July 18. | 68 39.6 | 4.793 |
| Tuscumbia. | 38 12 | 92 30 | 1881 | July 22. | 68 08.5 | 4.897 |
| Canaan. | 38 19 | 91 32 | 1881 | July 16. | 68 47.3 | 4.800 |
| Lincoln. | 38 23 | 93 21 | 1881 | Aug. 8. | 68 22.6 | 4.871 |
| Roedersville. | 38 24 | 91 10 | 1881 | July 9, 10. | 69 00.5 | 4.798 |

*intensities in the United States and adjacent regions.—Continued.*

MISSISSIPPI—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| ---- | ---- | 6.20 | ---- | J. E. Hilgard and J. S. Harris. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 61.7 | 5.87 | 12.38 | J. N. Nicollet. | C. S. Rpt., 1864, App. 19. Dip obs'd in Mar., horiz. intensity in May. |
| ---- | | | | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14. Nat. Acad. Ser. |
| ---- | ---- | 5.66 | ---- | Do. | Do. |
| ---- | 62.4 | 5.75 | 12.41 | Do. | Do. |
| ---- | 64.3 | 5.51 | 12.71 | Do. | Do. |
| ---- | 65.1 | 5.41 | 12.85 | Do. | Do. |
| ---- | | | | Do. | Do. |
| ---- | | | | B. B. Jenkins. | MS. communication. |
| ---- | 65.8 | 5.25 | 12.81 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14. Nat. Acad. Ser. |

MISSOURI.

| | | | | | |
|---|---|---|---|---|---|
| ---- | ---- | 5.02 | ---- | F. E. Nipher. | St. Louis Acad. Sc. |
| ---- | ---- | 5.01 | ---- | Do. | Do. |
| ---- | 67.08 | 5.03 | 12.92 | Do. | Do. |
| ---- | 67.63 | 4.95 | 13.01 | Do. | Do. |
| ---- | 67.47 | 4.94 | 12.89 | Do. | Do. |
| ---- | 67.44 | 5.00 | 13.03 | Do. | Do. |
| ---- | 67.03 | 5.11 | 13.10 | Do. | Do. |
| ---- | 67.12 | 5.03 | 12.94 | Do. | Do. |
| ---- | 67.71 | 4.96 | 13.08 | Do. | Do. |
| ---- | 67.70 | 4.99 | 13.15 | Do. | St. Louis Acad. Sc., Vol. IV. |
| ---- | 69.84 | 4.60 | 13.35 | Do. | St. Louis Acad. Sc. |
| ---- | | | | Do. | Do. |
| ---- | 67.83 | 4.95 | 13.12 | Do. | St. Louis Acad. Sc., Vol. IV. |
| ---- | 67.88 | 4.95 | 13.15 | Do. | St. Louis Acad. Sc. |
| ---- | 67.78 | 4.97 | 13.15 | Do. | Do. |
| ---- | | | | Do. | Do. |
| ---- | 68.40 | 4.89 | 13.28 | Do. | Do. |
| ---- | 68.16 | 4.86 | 13.06 | Do. | St. Louis Acad. Sc., Vol. IV. |
| ---- | 68.16 | 4.90 | 13.17 | Do. | St. Louis Acad. Sc. |
| ---- | 68.16 | 4.89 | 13.15 | Do. | Do. |
| ---- | 68.08 | 4.90 | 13.13 | Do. | St. Louis Acad. Sc., Vol. IV. |
| ---- | 68.61 | 4.79 | 13.13 | Do. | St. Louis Acad. Sc. |
| ---- | 68.22 | 4.93 | 13.29 | Do. | St. Louis Acad. Sc., Vol. IV. |
| ---- | 68.54 | 4.79 | 13.09 | Do. | Do. |
| ---- | 68.02 | 4.90 | 13.09 | Do. | Do. |
| ---- | 68.67 | 4.80 | 13.20 | Do. | Do. |
| ---- | 68.26 | 4.87 | 13.15 | Do. | Do. |
| ---- | 68.89 | 4.80 | 13.33 | Do. | Do. |

**TABLE I.—*Observed magnetic dips and horizontal and total magnetic***

MISSOURI—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Wulfert's farm. | 38 24 | 91 16 | 1881 | July 15. | ---- | 4.794 |
| Union. | 38 25 | 90 59 | 1881 | July 8. | 68 56.2 | 4.765 |
| Versailles. | 38 25 | 92 53 | 1881 | July 25. | 68 45.2 | 4.796 |
| Meramec River. | 38 26 | 90 12 | 1819 | June 8. | 70 00 | ---- |
| Pacific. | 38 28.2 | 90 43.8 | 1880 | July 27. | 69 02.3 | 4.722 |
| Washington. | 38 31.2 | 90 58.9 | 1879 | Aug. 15. | 69 07.6 | 4.737 |
| Windsor. | 38 32 | 93 33 | 1881 | Aug. 9. | 68 26.2 | 4.820 |
| Jefferson City. | 38 34.8 | 92 09.0 | 1879 | Aug. 10–13. | 68 55.7 | 4.744 |
| Cote sans dessein. | 38 36 | 91 56 | 1819 | July 6. | 70 50 | ---- |
| St. Louis. | 38 36 | 90 12 | 1819 | June 16. | 70 30 | ---- |
| Saint Louis, H. Chauteau's garden. | 38 37.5 | 90 12.0 | 1835<br>1836 | Aug.<br>June. | 69 10 | 4.814 |
| St. Louis. | 38 38 | 90 12 | 1839 | Sept. 6. | 69 31.4 | 4.748 |
| St. Louis, 1 mile west of city. | 38 38 | 90 12 | 1841 | Sept. | 69 25.5 | ---- |
| St. Louis, H. Chauteau's orchard about ½ mile from river. | 38 37.5 | 90 12.0 | 1841 | Oct. 11. | 69 27.1 | ---- |
| Saint Louis. | 38 38 | 90 12 | 1856 | Nov. 1. | 68 01 | 4.925 |
| Saint Louis, Compton Hill. | 38 37.1 | 90 14.0 | 1872 | June, July. | 69 34.4 | 4.629 |
| Saint Louis, three different localities. | 38 38.0 | 90 12.3 | 1878 | May 27, 28, 30. | 69 18.7 | ---- |
| Saint Louis, Washington Avenue and Eighteenth street. | 38 38 | 90 12 | 1878 | July 10; Oct. 11. | ---- | 4.586 |
| Saint Louis. | 38 38.0 | 90 12.3 | 1879 | Sept. 3, 9. | ---- | 4.673 |
| Holden. | 38 37.8 | 94 03.0 | 1879 | Aug. 17, 19. | 68 29.3 | 4.848 |
| California. | 38 39 | 92 38 | 1881 | Aug. 22. | 68 46.7 | 4.743 |
| Zimmerman's place. | 38 41 | 93 34 | 1881 | Aug. 10, 11. | 68 13.2 | 4.938 |
| Near Clayton, Saint Charles' Rockroad. | 38 41 | 90 19 | 1881 | July 4. | ---- | 4.601 |
| Hermann, on hill southeast of depot. | 38 42 | 91 27 | 1872 | Sept. 29. | 69 21.3 | 4.666 |
| Sedalia, ¾ mile south of depot. | 38 42 | 93 13 | 1872 | Oct. 2. | 68 48.5 | 4.780 |
| Sedalia. | 38 42.2 | 93 15.5 | 1878 | Sept. 7, 8. | 68 54.7? | 4.715 (?) |
| Do. | 38 42.2 | 93 15.5 | 1879 | Aug. 8. | 68 49.7 | 4.813 |
| Marion. | 38 42 | 92 25 | 1881 | Aug. 26. | 68 48.1 | 4.750 |
| Dardenne. | 38 43 | 90 42 | 1881 | Sept. 3. | 69 02.7 | 4.757 |
| Bellefontaine. | 38 43 | 90 12 | 1819 | June 23. | 70 00 | ---- |
| Pattonsville, opposite Saint Charles. | 38 43 | 90 30 | 1881 | Sept. 4, 6. | 69 39.6 | 4.612 |
| Opposite Saint Charles. | 38 44 | 90 31 | 1881 | Sept. 4. | 70 08.0 | 4.512 |
| Saint Charles. | 38 46 | 90 28 | 1819 | June 25. | 70 05 | ---- |
| Do. | 38 45.0 | 90 29.8 | 1878 | July 10, 11. | 69 29.9 | 4.497 |

*intensities in the United States and adjacent regions.—Continued.*

MISSOURI—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ (°) | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| ---- | ---- | 4.79 | ---- | F. E. Nipher. | St. Louis Acad. Sc., Vol. IV. |
| ---- | 68.82 | 4.77 | 13.20 | Do. | Do |
| ---- | 68.63 | 4.80 | 13.17 | Do. | Do |
| ---- | 68.7 | ---- | ---- | S. H. Long, U. S. A. | Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823; Sill. J., Vol. XXXIV., 1838, Loomis. Applied correction of + 36′ to longitude. |
| ---- | 68.89 | 4.72 | 13.10 | F. E. Nipher. | St. Louis Acad. Sc. |
| ---- | 68.95 | 4.74 | 13.20 | F. E. Nipher. | St. Louis Acad. Sc. |
| ---- | 68.32 | 4.82 | 13.04 | Do. | St. Louis Acad. Sc., Vol. IV. |
| ---- | 68.75 | 4.74 | 13.08 | Do. | St. Louis Acad. Sc. |
| ---- | 69.5 | ---- | ---- | S. H. Long, U. S. A. | Maj. Long's Exp. to Rocky Mts. 2 vols. Phila., 1823; Sill. J., Vol. XXXIV, 1838. Loomis. |
| ---- | | | | Do. | Maj. Long's Exp. to Rocky Mts. 2 vols. Phila., 1823; Sill. J., Vol. XXXIV, 1838. Loomis. Applied Cor'n of + 36′ to longitude. |
| ---- | | | | J. N. Nicollet. | C. S. Rpt., 1864; θ = mean value, 1835 Aug. & 1836 June, Epoch 1836.0. |
| 13.58 | | | | J. Locke. | Sill. J., Vol. XXXIX, 1840; Am. Phil. Soc., 1846, Art. XI. |
| ---- | | | | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | 69.17 | 4.63 | 13.02 | J. N. Nicollet. | Do. |
| 13.147 | | | | K. Friesach. | K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858. Intensities converted into Eng. units. The dip appears to be defective. |
| ---- | | | | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| ---- | | | | F. E. Nipher. | St. Louis Acad. Sc. Mean of 3 values. |
| ---- | | | | Do. | St. Louis Acad. Sc. Five stations occupied, of which Sta. 2 apparently least affected by local disturbance. |
| ---- | | | | Do. | St. Louis Acad. Sc. |
| ---- | 68.31 | 4.85 | 13.13 | Do. | Do. |
| ---- | 68.66 | 4.74 | 13.03 | Do. | St. Louis Acad. Sc., Vol. IV. |
| ---- | 68.10 | 4.94 | 13.24 | Do. | Do. |
| ---- | ---- | 4.60 | ---- | Do. | Do. |
| ---- | 69.03 | ---- | ---- | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| ---- | | | | Do. | Do. |
| ---- | 68.61 | 4.81 | 13.19 | F. E. Nipher. | St. Louis Acad. Sc. |
| ---- | | | | Do. | Do. |
| ---- | 68.68 | 4.75 | 13.07 | Do. | St. Louis Acad. Sc., Vol. IV. |
| ---- | 68.92 | 4.76 | 13.23 | Do. | Do. |
| ---- | 69.3 | ---- | ---- | S. H. Long, U. S. A. | Maj. Long's Exp. to Rocky Mts. 2 vols. Phila., 1823; Sill. J., Vol. XXXIV, 1838. Loomis. Longitude cor'd by + 36′. |
| ---- | | | | F. E. Nipher. | St. Louis Acad. Sc. |
| ---- | | | | Do. | St. Louis Acad. Sc., Vol. IV. |
| ---- | 69.60 | 4.51 | 12.94 | S. H. Long, U. S. A. | Maj. Long's Exp. to Rocky Mts. 2 vols. Phila., 1823; Sill. J., Vol. XXXIV, 1838. Applied cor'n of + 40′ to longitude. |
| ---- | | | | F. E. Nipher. | St. Louis Acad. Sc. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MISSOURI—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Warrenton. | 38 46 | 91 08 | 1881 | Sept. 2. | 69 10.4 | 4.697 |
| O'Fallon. | 38 46.8 | 90 43.2 | 1880 | Oct. 31. | ---- | 4.670 |
| Florissant. | 38 47 | 90 17 | 1881 | Sept. 6. | ---- | 4.608 |
| Wright City. | 38 47.1 | 91 00 | 1878 | July 12. | 69 11.2 | 4.616 |
| Providence. | 38 49 | 92 28 | 1881 | Aug. 27. | 69 00.3 | 4.737 |
| Clark's Fork. | 38 51 | 92 40 | 1881 | Aug. 20. | 69 15.9 | 4.724 |
| Sweet Springs. | 38 55 | 93 29 | 1881 | Aug. 13. | 68 57.4 | 4.753 |
| Columbia. | 38 56.5 | 92 20.2 | 1878 | July 15, 17. | 69 19.1 | 4.670 |
| Franklin. | 38 57 | 92 57 | 1819 | July 17. | 69 30 | ---- |
| McCredie. | 38 59 | 91 55 | 1881 | Aug. 30. | 69 05.0 | 4.717 |
| Herndon. | 39 00 | 93 21 | 1881 | Aug. 15. | ---- | 4.734 |
| Arrow Rock. | 39 06 | 93 00 | 1881 | Aug. 18. | ---- | 4.653 |
| Camp on Missouri River. | 39 06 | 93 00 | 1819 | July 28. | 69 45 | ---- |
| Kansas City. | 39 05 | 94 38 | 1872 | Oct. 4. | 69 05.3 | 4.773 |
| Do. | 39 07.2 | 94 37.7 | 1878 | Sept. 3, 4, 6. | 69 13.8 | 4.627 |
| Do. | 39 07.2 | 94 37.7 | 1879 | July 29. | 68 58.6 | 4.783 |
| Marshall. | 39 08 | 93 17 | 1881 | Aug. 16. | 69 34.0 | 4.660 |
| Charaton. | 39 10 | 92 20 | 1819 | July 24. | 69 50 | ---- |
| Fort Osage. | 39 10 | 94 18 | 1819 | Aug. 4. | 69 18 | ---- |
| Mexico. | 39 11.1 | 91 52.1 | 1878 | July 13. | 69 27.6 | 4.728 |
| Lexington. | 39 11.5 | 93 52.9 | 1879 | Aug. 21, 22. | 69 13.7 | 4.712 |
| Glasgow. | 39 13.3 | 92 49.6 | 1879 | July 21, 22. | 69 57.4 | 4.575 |
| Carrollton. | 39 21.1 | 93 32.8 | 1879 | July 28. | 69 29.0 | 4.680 |
| Cow Island. | 39 25 | 94 00 | 1819 | Aug. 20. | 69 50 | ---- |
| Louisiana. | 39 27.2 | 91 03.1 | 1878 | Nov. 20, 21, 22. | 69 57.7 | ---- |
| Do. | 39 28.0 | 91 06.7 | 1878 | July 20, 21. | 69 50.2 | 4.576 |
| Hannibal. | 39 44.1 | 91 23.7 | 1878 | July 22. | 70 14.3 | 4.525 |
| St. Joseph. | 39 45.6 | 94 49.2 | 1879 | July 31. | 69 43.3 | 4.657 |
| Macon. | 39 46.4 | 92 29.6 | 1878 | Aug. 6. | 70 07.6 | 4.521 |
| Chillicothe. | 39 47.4 | 93 34.5 | 1879 | July 25. | 70 19.3 | 4.527 |
| Canton. | 40 08.6 | 91 35.6 | 1878 | July 24, 27. | 70 27.8 | 4.442 |
| Kirksville. | 40 11.7 | 92 36.7 | 1878 | Aug. 3, 5. | 70 40.6 | 4.416 |
| Memphis. | 40 27.3 | 92 13.3 | 1878 | Aug. 1, 2. | 70 26.8 | 4.477 |
| Marysville. | 40 21.0 | 94 57.5 | 1879 | Aug. 2, 3, 4. | 70 05.8 | 4.538 |

***intensities in the United States and adjacent regions.—Continued.***

MISSOURI—Continued.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| ---- | 69.05 | 4.70 | 13.15 | F. E. Nipher. | St. Louis Acad. Sc., Vol. IV. |
| ---- | ---- | 4.67 | ---- | Do. | St. Louis Acad. Sc. |
| ---- | ---- | 4.61 | ---- | Do. | St. Louis Acad. Sc., Vol. IV. |
| ---- | 68.98 | 4.62 | 12.88 | Do. | St. Louis Acad. Sc. |
| ---- | 68.88 | 4.74 | 13.16 | Do. | St. Louis Acad. Sc., Vol. IV. |
| ---- | 69.14 | 4.72 | 13.26 | Do. | Do. |
| ---- | 68.84 | 4.75 | 13.16 | Do. | Do. |
| ---- | 69.10 | 4.67 | 13.09 | Do. | St. Louis Acad. Sc. |
| ---- | 68.8 | ---- | ---- | S. H. Long, U. S. A. | Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823; Sill. J., Vol. XXXIV, 1838. (Loomis.) |
| ---- | 66.96 | 4.72 | 12.06 | F. E. Nipher. | St. Louis Acad. Sc., Vol. IV. |
| ---- | ---- | 4.73 | ---- | Do. | Do. |
| ---- | } 69.0 | 4.65 | 12.98 { | F. E. Nipher. | Do. |
| ---- | | | | S. H. Long, U. S. A. | Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823; Sill. J., Vol. XXXIV, 1838. (Loomis.) Longitude apparently doubtful. |
| ---- | ---- | ---- | ---- | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser. |
| ---- | } 68.88 | 4.72 | 13.10 { | F. E. Nipher. | St. Louis Acad. Sc. |
| ---- | | | | Do. | Do. |
| ---- | 69.45 | 4.66 | 13.28 | Do. | St. Louis Acad. Sc., Vol. IV. |
| ---- | 69.1 | ---- | ---- | S. H. Long, U. S. A. | Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823; Sill. J., Vol. XXXIV, 1838. (Loomis.) Longitude apparently doubtful. |
| ---- | 68.6 | ---- | ---- | Do. | Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823; Sill. J., Vol. XXXIV, 1838. (Loomis.) |
| ---- | 69.24 | 4.73 | 13.35 | F. E. Nipher. | St. Louis Acad. Sc. |
| ---- | 69.05 | 4.71 | 13.17 | Do. | Do. |
| ---- | 69.78 | 4.58 | 13.25 | Do. | Do. |
| ---- | 69.30 | 4.68 | 13.24 | Do. | Do. |
| ---- | 69.1 | ---- | ---- | S. H. Long, U. S. A. | Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823; Sill. J., Vol. XXXIV, 1838. (Loomis.) |
| ---- | } 69.68 | 4.58 | 13.19 { | C. F. Powell. | U. S. Lake Sur. Rpt., 1879. |
| ---- | | | | F. E. Nipher. | St. Louis Acad. Sc. |
| ---- | 70.02 | 4.53 | 13.26 | Do. | Do. |
| ---- | 69.54 | 4.66 | 13.33 | Do. | Do. |
| ---- | 69.92 | 4.52 | 13.17 | Do. | Do. |
| ---- | 70.14 | 4.53 | 13.34 | Do. | Do. |
| ---- | 70.25 | 4.44 | 13.14 | Do. | Do. |
| ---- | 70.46 | 4.42 | 13.21 | Do. | Do. |
| ---- | 70.23 | 4.48 | 13.25 | Do. | Do. |
| ---- | 69.92 | 4.54 | 13.23 | Do. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MONTANA.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Fort Ellis. | 45 40 | 110 58 | 1882 | Aug. 30. | 71 43.4 | 4.248 |
| Fort Custer. | 45 45 | 107 48 | 1882 | July 23. | 72 23.4 | 4.167 |
| South Crossing, Kootenay River. | 48 22 | 115 21 | 1861 | July 6. | 72 48.1 | 3.9731 |
| Kootenay River. | 48 40 | 115 17 | 1861 | July 12. | 73 07.2 | ---- |
| Tobacco Plains, Kootenay. | 48 57 | 115 08 | 1861 | Aug. 19. | 73 22.9 | ---- |
| Camp Kootenay East. | 48 59 | 115 12 | 1861 | ---- | 73 11 | 3.850 |
| Camp Kishenehu. | 49 00 | 114 21 | 1861 | ---- | 73 46.8 | 3.790 |

NEBRASKA.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Big Sandy River. | 40 12 | 97 12 | 1858 | Aug. | 69 33 | ---- |
| Little Blue River. | 40 15 | 98 10 | 1858 | Aug. | 69 51 | ---- |
| Fort Kearney. | 40 38 | 98 56 | 1858 | Sept. | 70 15 | ---- |
| Camp No. 20. | 40 40 | 99 54 | 1858 | Sept. | 69 37 | ---- |
| Grand Island, ¾ mile N. W. of depot. | 40 55 | 98 23 | 1872 | Oct. 27. | 70 15.5 | 4.535 |
| Grand Island. | 40 55.4 | 98 17.6 | 1878 | Aug. 28. | 70 17.7 | 4.5675 |
| Camp No. 22. | 41 05 | 100 50 | 1858 | Sept. | 69 46 | ---- |
| Sidney. | 41 08 | 102 55 | 1872 | Oct. 25. | 69 23.9 | 4.640 |
| North Platte. | 41 11 | 100 45 | 1872 | Oct. 26. | 69 41.1 | 4.585 |
| Omaha. | 41 15.7 | 95 56.5 | 1869 | Jan. 25–Feb. 1. | 71 04.5 | 4.314 |
| Omaha, on hill southwest of Brownell School. | 41 16 | 95 56 | 1872 | Oct. 31. | 71 06.1 | 4.320 |
| Omaha. | 41 15.7 | 95 56.5 | 1877 | Oct. 13–20. | 71 05.8 | 4.408 |
| Do. | 41 15.7 | 95 56.5 | 1880 | Oct. 15, 17. | 71 05.9 | 4.375 |
| Ash Hollow. | 41 21 | 102 03 | 1858 | Sept. | 70 03 | ---- |
| Chimney Rock. | 41 43 | 103 30 | 1858 | Sept. | 70 05 | ---- |

NEVADA.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Pioche. | 37 59.1 | 114 03.1 | 1883 | Sept. 24–28. | 65 36 | 5.162 |
| White Pine Station. | 38 19.1 | 115 30.1 | 1881 | Nov. 14–23. | 64 04.1 | 5.389 |
| Jeff. Davis. | 38 59.1 | 114 18.8 | 1882 | Nov. 19–23. | 64 59.9 | 5.270 |
| Genoa, Carson Valley. | 39 00 | 119 40 | 1859 | ---- | 64 12 | ---- |
| Tres Pinos, Lehman's Cañon. | 39 00.5 | 114 14.1 | 1882 | Dec. 1, 2, 3. | 65 00.8 | 5.273 |
| Lehman's Ranch, Snake Valley. | 39 00.6 | 114 08.2 | 1882 | Dec. 9, 10, 11. | 65 02.4 | 5.287 |
| Big Bend, Walker's River. | 39 09 | 118 56 | 1859 | ---- | 63.37 | ---- |
| Carson Lake. | 39 24 | 118 30 | 1859 | ---- | 64 02 | ---- |
| Austin, hill back of Chinatown. | 39 28.9 | 117 04.0 | 1881 | May 31; June 1, 2. | 64 49.0 | 5.254 |
| Reese River.* | 39 29 | 117 03 | 1858 | ---- | 64 25 | ---- |
| Reno, near Court-House. | 39 30.5 | 119 48.7 | 1881 | Apr. 11, 12, 13. | 64 14.1 | 5.317 |

* Dip changed from 69° 25′ to 64° 25′ for supposed printing error.

*intensities in the United States and adjacent regions—Continued.*

MONTANA.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| 13.546 | 71.70 | 4.25 | 13.54 | B. A. Colonna. | MS. in C. & G. S. Office. |
| 13.774 | 72.36 | 4.17 | 13.76 | Do. | Do. |
| 13.435 | 72.8 | ---- | ---- | R. W. Haig. | B. S.; Phil. Trans. R. S., 1864. θ, H, F, obs'd. |
| 13.443 | 73.1 | ---- | ---- | Do. | Do. |
| 13.477 | } 73.3 | ---- | ---- { | Do. | Do. |
| ---- | | | | J. S. Harris. | U. S. NW. Bound. Com.; MS. in C. S. Office. |
| ---- | 73.7 | ---- | ---- | Do. | Do. |

NEBRASKA.

| | | | | | |
|---|---|---|---|---|---|
| ---- | 69.6 | ---- | ---- | J. H. Simpson. | J. B. Stone's "Magnetic Variation," New York, 1878. |
| ---- | 69.8 | ---- | ---- | Do. | Do. |
| ---- | 70.2 | ---- | ---- | Do. | Do. |
| ---- | 69.6 | ---- | ---- | Do. | Do. |
| ---- | } 70.28 | 4.56 | 13.52 { | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14. |
| 13.546 | | | | T. E. Thorpe. | Proc. R. S., No. 200, 1880. |
| ---- | 69.8 | ---- | ---- | J. H. Simpson. | J. B. Stone's "Magnetic Variation," New York, 1878. |
| ---- | 69.4 | 4.64 | 13.19 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14. |
| ---- | 69.7 | 4.59 | 13.23 | Do. | Do. |
| 13.30 | } 71.05 | 4.39 | 13.52 { | E. Goodfellow. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14. |
| 13.61 | | | | A. Braid. | C. & G. S. Rpt., 1881, App. 9. |
| 13.50 | | | | J. B. Baylor. | Do. |
| ---- | 70.0 | ---- | ---- | J. H. Simpson. | J. B. Stone's "Magnetic Variation," New York, 1878. |
| ---- | 70.1 | ---- | ---- | Do. | Do. |

NEVADA.

| | | | | | |
|---|---|---|---|---|---|
| 12.50 | 65.5 | 5.158 | 12.44 | W. Eimbeck and G. F. Bird. | MS. in C. & G. S. Office. |
| 12.32 | 64.0 | 5.381 | 12.28 | W. Eimbeck and R. A. Marr. | C. & G. S. Rpt., 1881, App. 9. |
| 12.47 | 64.9 | 5.264 | 12.41 | Do. | MS. in C. & G. S. Office. |
| ---- | ---- | ---- | ---- | J. H. Simpson. | Mag. Var., by J. B. Stone, New York, 1878. |
| 12.48 | } 65.0 | 5.275 | 12.48 { | W. Eimbeck and R. A. Marr. | MS. in C. & G. S. Office. |
| 12.53 | | | | Do. | Do. |
| ---- | ---- | ---- | ---- | J. H. Simpson. | Mag. Var., by J. B. Stone, New York, 1878. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| 12.34 | } 64.8 | 5.245 | 12.32 { | W. Eimbeck and R. A. Marr. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | J. H. Simpson. | Mag. Var., by J. B. Stone, New York, 1878. |
| 12.23 | 64.2 | 5.308 | 12.20 | W. Eimbeck and R. A. Marr. | C. & G. S. Rpt., 1881, App. 9. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

NEVADA—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Verdi. | 39 31. 1 | 119 57. 8 | 1872 | July 28, 29. | 63 58. 6 | 5. 303 (?) |
| Eureka, town, on Story's Hill. | 39 31. 1 | 115 58. 2 | 1881 | May 19, 21, 22. | 65 08. 4 | 5. 218 |
| Eureka Station. | 39 35. 1 | 115 49. 1 | 1881 | Sept. 13–29. | 65 12. 3 | 5. 209 |
| Mount Callahan Station. | 39 42. 6 | 116 57. 0 | 1881 | July 12, 20. | 65 07. 4 | 5. 221 |
| Ko-bah Valley. | 39 44 | 116 10 | 1858 | ---- | 64 56 | ---- |
| Hot Springs, opposite railroad office. | 39 46. 9 | 118 55. 5 | 1881 | Apr. 15, 16. | 64 46. 5 | 5. 271 |
| Antelope Valley. | 39 47 | 114 12 | 1859 | ---- | 65 16 | ---- |
| Cho-Keep Pass. | 39 54 | 115 45 | 1858 | ---- | 65 19 | ---- |
| Huntingdon's Spring. | 40 01 | 115 19 | 1859 | ---- | 65 25 | ---- |
| Mineral Hill. | 40 09. 8 | 116 12. 0 | 1881 | May 23, 24, 25. | 65 40. 7 | 5. 151 |
| Rye Patch, north of railroad office and hotel. | 40 26. 0 | 118 18. 5 | 1881 | Apr. 18, 19. | 65 23. 9 | 5. 159 |
| Battle Mountain, hotel garden. | 40 40. 3 | 116 50. 0 | 1881 | Apr. 23, 24, 25. | 65 51. 2 | 5. 116 |
| Elko, grounds of Nevada State University. | 40 47. 4 | 115 45. 5 | 1881 | Apr. 26, 27, 28. | 66 23. 0 | 5. 043 |
| Winnemucca, near court-house. | 40 58. 9 | 117 44. 0 | 1881 | Apr. 21, 22. | 65 59. 2 | 5. 114 |
| Wells' Station, near public school building. | 41 07. 0 | 114 56. 0 | 1881 | Apr. 29, 30. | 66 49. 9 | 4. 989 |
| Tecoma, near Peck's Hotel. | 41 19. 5 | 114 06. 0 | 1881 | May 1, 2. | 67 08. 0 | 4. 947 |

NEW HAMPSHIRE.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Troy. | 42 49. 7 | 72 10. 9 | 1861 | Aug. 19–22. | 74 45. 7 | 3. 578 |
| Monadnock. | 42 51. 7 | 72 06. 5 | 1861 | July 31; Aug. 2, 3. | 74 44. 4 | ---- |
| Chesterfield, about one mile east of factory village. | 42 54. 0 | 72 26. 0 | 1874 | Oct. 4. | 74 24. 7 | 3. 599 |
| Isles of Shoals, Hog Island. | 42 59. 2 | 70 36. 8 | 1847 | Aug. 17, 18, 26, 27. | 74 44. 1 | 3. 482 |
| Unkonoonuc. | 42 59. 0 | 71 35. 3 | 1848 | Oct. 9, 10. | 75 08. 7 | 3. 476 |
| Portsmouth. | 43 04. 5 | 70 44 | 1844 | ---- | 74 51. 0 | ---- |
| Portsmouth, Jamaica Island. | 43 04. 5 | 70 44 | 1844 | ---- | 74 47. 7 | ---- |
| Portsmouth, near North Base. | 43 03 | 70 44 | 1844 | ---- | 74 38. 0 | ---- |
| Portsmouth, Shelliby's field. | 43 04 | 70 47 | 1844 | ---- | 74 53. 7 | ---- |
| Portsmouth. | 43 04 | 70 45 | 1844 | ---- | 74 58. 2 | ---- |
| Portsmouth, on Tree Island. | 43 04. 5 | 70 45 | 1844 | ---- | 74 57. 4 | ---- |
| Patuccawa. | 43 07. 2 | 71 11. 8 | 1849 | Aug. 15–19. | 76 49. 5 | 3. 093 |
| Gunstock. | 43 31. 1 | 71 22. 2 | 1860 | July 25; Aug. 4. | 75 43. 6 | 3. 401 |
| Hanover. | 43 42. 3 | 72 17. 1 | 1873 | Oct. 4–10. | 75 21. 1 | 3. 455 |
| Hanover, hill north of observatory. | 43 42. 3 | 72 17. 1 | 1879 | Oct. 6. | 74 55. 8 | 3. 478 |
| Hanover, about ¾ mile west of observatory. | 43 42. 3 | 72 18. 0 | 1879 | Oct. 7. | 75 02. 7 | 3. 473 |
| Near Mount Washington. | 44 15 | 71 18 | 1845 | June. | 75 40. 0 | ---- |
| Mount Washington. | 44 16. 2 | 71 18. 2 | 1845 | June 18. | 75 45. 0 | 3. 314 |
| Camp on Mount Washington, 1 mile west of summit. | 44 16 | 71 19 | 1845 | June 19. | 75 50. 8 | 3. 316 |

*intensities in the United States and adjacent regions—Continued.*

NEVADA—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 12.09(?) | (63.9)° | 5.267 | (11.97) | G. Davidson and S. R. Throckmorton. | C. & G. S. Rpt., 1881, App. 9. |
| 12.41 | 65.1 | 5.209 | 12.37 | W. Eimbeck and R. A. Marr. | Do. |
| 12.42 | 65.1 | 5.201 | 12.35 | Do. | Do. |
| 12.41 | 65.1 | 5.212 | 12.38 | Do. | Do. |
| ---- | ---- | ---- | ---- | J. H. Simpson. | Mag. Var., by J. B. Stone, New York, 1878. |
| 12.37 | 64.7 | 5.262 | 12.31 | W. Eimbeck and R. A. Marr. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | ---- | ---- | ---- | J. H. Simpson. | Mag. Var., by J. B. Stone, New York, 1878. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| 12.51 | 65.6 | 5.142 | 12.45 | W. Eimbeck and R. A. Marr. | C. & G. S. Rpt., 1881, App. 9. |
| 12.39 | 65.4 | 5.150 | 12.37 | Do. | Do. |
| 12.51 | 65.8 | 5.107 | 12.46 | Do. | Do. |
| 12.59 | 66.3 | 5.034 | 12.52 | Do. | Do. |
| 12.57 | 65.9 | 5.105 | 12.50 | Do. | Do. |
| 12.68 | 66.7 | 4.980 | 12.59 | Do. | Do. |
| 12.73 | 67.0 | 4.938 | 12.64 | Do. | Do. |

NEW HAMPSHIRE.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 13.61 | 73.76 | 3.690 | 13.20 | G. W. Dean, R. E. Halter, and A. D. Bache. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 73.74 | ---- | ---- | Do. | Do. |
| 13.39 | 73.68 | 3.640 | 12.95 | T. C. Hilgard. | Do. |
| 13.22 | 73.83 | 3.564 | 12.80 | T. J. Lee. | Do. |
| 13.56 | 74.23 | 3.567 | 13.13 | J. S. Ruth. | Do. |
| ---- | 73.98 (for the next six rows) | ---- | ---- | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| ---- | | | | J. D. Graham and A. W. Whipple. | Phil. Trans. R. S., 1846. |
| ---- | | | | Do. | Do. |
| ---- | | | | Do. | Do. |
| ---- | | | | Do. | Do. |
| ---- | | | | Do. | Do. |
| 13.57 | 75.91 | 3.19 | 13.12 | C. O. Boutelle. | C. & G. S. Rpt., 1881, App. 9. |
| 13.80 | 74.73 | 3.518 | 13.36 | G. W. Dean and A. D. Bache. | Do. |
| 13.66 | 74.56 (for the next three rows) | 3.497 | 13.14 | T. C. Hilgard. | Do. |
| 13.38 | | | | J. B. Baylor. | Do. |
| 13.46 | | | | Do. | Do. |
| 13.47 | 74.88 (for the next three rows) | 3.381 | 12.96 | J. Locke. | Phil. Trans. R. S., 1846; Smithsonian Cont's to Know., Vol. III, 1852. |
| 13.47 | | | | Do. | Do. |
| ---- | | | | Do. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

NEW HAMPSHIRE—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Fabyan Hotel, 7 miles west of Mount Washington. | 44 16 | 71 25 | 1845 | June 20. | 75 39.9 | 3.336 |
| Glen House, 4 miles east of Mount Washington. | 44 16 | 71 14 | 1856 | Aug. 11. | 75 56 | ---- |
| Littleton, on rock near Oak Hill House. | 44 19.0 | 71 48.0 | 1873 | Sept. 28–Oct. 1. | 75 39.1 | 3.378 |
| Gorham, at Soldiers' Hill. | 44 22.5 | 71 15.0 | 1873 | Sept. 20–25. | 75 35.6 | 3.410 |
| Gorham. | 44 27 | 71 13 | 1845 | June 17. | 75 33.4 | 3.385 |
| Hall's stream. | 45 01 | 71 30 | 1845 | ---- | 76 23.5 | ---- |

NEW JERSEY.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Cape May light-house. | 38 55.8 | 74 58.0 | 1846 | June 29. | 71 25.8 | 4.255 |
| Do. | 38 55.8 | 74 58.0 | 1855 | Aug. 3. | 71 34.4 | 4.182 |
| Do. | 38 55.8 | 74 58.0 | 1874 | June 27. | 71 28.5 | 4.283 |
| Townbank. | 38 58.6 | 74 57.7 | 1846 | June 30. | 71 23.6 | 4.269 |
| Egg Island light-house. | 39 10.5 | 75 08.4 | 1846 | June 25. | 71 45.1 | 4.206 |
| Port Norris. | 39 14.6 | 75 01.3 | 1846 | June 23. | 71 39.6 | 4.211 |
| Atlantic City. | 39 21.8 | 74 24.9 | 1860 | Aug. 22, 23. | 71 47.0 | 4.205 |
| Pine Mount. | 39 25.0 | 75 20.3 | 1846 | June 19. | 71 41.4 | 4.237 |
| Hawkins. | 39 25.6 | 75 17.3 | 1846 | June 20. | 71 42.6 | 4.224 |
| Long Beach. | 39 32.0 | 74 15.6 | 1860 | Aug. 24–28. | 71 58.5 | 4.156 |
| Tuckerton. | 39 36.1 | 74 19.8 | 1846 | Nov. 7, 9. | 72 12.3 | 4.063 |
| Church Landing. | 39 40.6 | 75 31.3 | 1846 | June 6. | 71 22.0 | 4.311 |
| Barnegat light-house. | 39 45.8 | 74 06.4 | 1860 | Aug. 25, 26. | 72 05.3 | 4.108 |
| Chew. | 39 48.2 | 75 10.1 | 1846 | July 14, 15. | 72 14.4 | 4.105 |
| White Hill. | 40 08.3 | 74 43.9 | 1846 | May 20. | 72 06.2 | 4.147 |
| Trenton. | 40 13 | 74 45 | 1841 | Apr. 23. | 71 59 | 4.196 |
| Princeton College. | 40 20.9 | 74 39.6 | 1839 | Sept. | 72 47.1 | 4.041 |
| Princeton, in field behind college. | 40 21 | 74 40 | 1842 | Oct. 14. | 72 43.5 | 4.010 |
| Princeton, near college. | 40 20.7 | 74 39.6 | 1843 | July. | 72 38.3 | 4.222 |
| Do. | 40 20.9 | 74 39.6 | 1844 | ---- | 72 39.5 | ---- |
| Do. | 40 20.9 | 74 39.6 | 1844 | May 23. | 72 40.2 | 4.016 |
| Princeton, Pott's Wood. | 40 22 | 74 39 | 1844 | May 23, 24. | { 72 41.4<br>72 41.2 | 4.017<br>3.999 |
| Princeton, Rocky Hill (Trap). | 40 23 | 74 39 | 1844 | May 24. | 72 35.0 | 4.049 |
| Mount Rose. | 40 22.2 | 74 43.3 | 1852 | Aug. 12–18. | 72 42.5 | 4.130 |
| Sandy Hook. | 40 27.7 | 74 00.2 | 1844 | Aug. | 72 37.9 | 4.077 |
| Do. | 40 27.7 | 74 00.3 | 1855 | Aug. 14. | 72 52.0 | 3.917 |
| Do. | 40 27.7 | 74 00.2 | 1873 | Nov. 5–9. | 72 29.6 | 4.040 |
| Do. | 40 27.7 | 74 00.2 | 1879 | July 17, 18. | 72 08.3 | 4.078 |

***intensities in the United States and adjacent regions.**—Continued.*

NEW HAMPSHIRE—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| ---- | 74.79 | 3.402 | 12.97 | J. Locke. | Phil. Trans. R. S., 1846; Smithsonian Cont's to Know., Vol. III, 1852. |
| ---- | 74.95 | ---- | ---- | K. Fritsach. | K. K. Acad. d. Wiss., Vienna, Vol. 29, 1858. |
| 13.63 | 74.88 | 3.423 | 13.12 | T. C. Hilgard. | C. & G. S. Rpt., 1881, App. 9. |
| 13.70 | 74.76 | 3.454 | 13.14 | Do. | Do. |
| 13.58 | | | | J. Locke. | Phil. Trans. R. S., 1846; Smithsonian Cont's to Know., Vol. III, 1852. |
| ---- | 75.52 | ---- | ---- | J. D. Graham. | Phil. Trans. R. S., 1846. |

NEW JERSEY.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 13.36 | | | | J. Locke. | C. & G. S. Rpt., 1881, App. 9. |
| 13.23 | 70.99 | 4.304 | 13.21 | C. A. Schott. | Do. |
| 13.48 | | | | T. C. Hilgard. | Do. |
| 13.38 | 70.88 | 4.334 | 13.23 | J. Locke. | Do. |
| 13.43 | 71.24 | 4.271 | 13.28 | Do. | Do. |
| 13.38 | 71.15 | 4.276 | 13.24 | Do. | Do. |
| 13.45 | 71.18 | 4.288 | 13.29 | C. A. Schott. | Do. |
| 13.49 | 71.18 | 4.296 | 13.32 | J. Locke. | Do. |
| 13.46 | | | | Do. | Do. |
| 13.43 | 71.37 | 4.240 | 13.27 | C. A. Schott. | Do. |
| 13.30 | 71.69 | 4.129 | 13.14 | T. J. Lee. | Do. |
| 13.49 | 70.86 | 4.377 | 13.35 | J. Locke. | Do. |
| 13.36 | 71.49 | 4.191 | 13.20 | C. A. Schott. | Do. |
| 13.46 | 71.73 | 4.171 | 13.31 | J. Locke. | Do. |
| 13.50 | 71.59 | 4.213 | 13.34 | Do. | Do. |
| 13.56 | 71.46 | 4.242 | 13.34 | Do. | Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844. |
| 13.55 | | | | E. Loomis. | Sill. J., Vol. XXXIX, 1840; Am. Phil. Soc., Vol. VIII. |
| 13.504 | | | | J. H. Lefroy. | Diary Mag. Sur. Canada, Gen'l Sir J. H. Lefroy, London, 1883. |
| ---- | | | | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| ---- | 72.17 | 4.110 | 13.42 | E. Loomis. | Phil. Trans. R. S., 1846. |
| 13.48 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844. |
| 13.50 | | | | Do. | Do. |
| 13.44 | | | | | |
| 13.53 | | | | Do. | Do. |
| 13.90 | 72.16 | 4.211 | 13.75 | J. E. Hilgard. | C. & G. S. Rpt., 1881, App. 9. |
| 13.66 | | | | J. Renwick. | Do. |
| 13.30 | | | | C. A. Schott. | Do. |
| 13.43 | 71.93 | 4.081 | 13.16 | T. C. Hilgard. | Do. |
| 13.30 | | | | J. B. Baylor. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

NEW JERSEY—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| New Brunswick. | 40 29.9 | 74 26.8 | 1844 | May 24. | 72 43.2 | 4.008 |
| Snake Hill, seven miles west of New York. | 40 43 | 74 06 | 1844 | Apr. | 72 45.4 | ---- |
| Newark. | 40 44 | 74 10 | 1841 | Apr. 19. | 72 48.5 | 3.999 |
| Newark, Washington place. | 40 44 | 74 10 | 1844 | Apr. 29. | 72 50.2 | 3.972 |
| Newark, on the Neck. | 40 44 | 74 09 | 1844 | Apr. 29. | 72 46.3 | 3.986 |
| Newark. | 40 44.8 | 74 10.0 | 1846 | May 16. | 72 52.2 | 3.964 |
| Fort Lee. | 40 50.8 | 73 57.7 | 1844 | Apr. | 72 41 | ---- |
| Paterson. | 40 56 | 74 10 | 1844 | Apr. | 72 17 to 75 00 | ---- |

NEW MEXICO.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| San Luis Springs. | 31 20 | 108 48 | 1855 | Apr. 19. | 57 37 | 6.265 |
| Agua del Perro. | 31 21 | 108 20 | 1855 | Apr. 3. | 57 28 | 6.156 |
| El Paso del Norte, Initial Point. | 31 47 | 106 28 | 1855 | Jan. 4. | 58 39 | 6.202 |
| Carrizalillo. | 31 51 | 107 56 | 1855 | March 1. | 58 31 | 6.125 |
| Doña Ana. | 32 22 | 106 47 | 1851 | ---- | 59 06 | ---- |
| IX. | 32 22 | 107 24 | 1851 | ---- | 59 09 | ---- |
| Ojo de Inez. | 32 45 | 108 14 | 1851 | -- | 59 18 | ---- |
| Copper Mines. | 32 47 | 108 04 | 1851 | ---- | 59 17 | ---- |
| Isleta. | 34 54 | 106 40 | 1853 | Nov. 9. | 62 24 | ---- |
| Rio San José. | 35 01 | 107 14 | 1853 | Nov. 12. | 63 18 | ---- |
| Cedar Forest. | 35 01 | 108 55 | 1853 | Nov. 28. | 61 40 | ---- |
| Agua Fria. | 35 02 | 107 58 | 1883 | Nov. 17. | 62 05 | ---- |
| Prescription Rock, north bluff of El Moro. | 35 03 | 108 14 | 1853 | Nov. 18. | 62 03 | ---- |
| Covero. | 35 05 | 107 26 | 1853 | Nov. 14. | 62 26 | ---- |
| Hay Camp, south side of stream. | 35 05 | 107 39 | 1853 | Nov. 15. | 62 39 | ---- |
| Arch Spring. | 35 05 | 108 48 | 1853 | Nov. 26. | 61 55 | ---- |
| Albuquerque. | 35 06 | 106 38 | 1853 | Oct. 17. | 62 28 | ---- |
| Zuni River. | 35 06 | 108 39 | 1853 | Nov. 22. | 62 02 | ---- |

NEW YORK.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Cole, Staten Island, geodetic station. | 40 31.9 | 74 14.1 | 1846 | May 11. | 72 34.2 | 4.028 |
| Fire Island light-house, Long Island. | 40 37.9 | 73 13.2 | 1848 | July 15. | ---- | 3.932 |
| Fire Island, west end of Fire Island base. | 40 37.8 | 73 12.9 | 1860 | Sept. 1, 2. | 73 00.2 | 3.900 |
| New York, Columbia College (old site). | 40 42.6 | 74 00.5 | 1822 | Dec. | 73 00.5 | 3.981 |
| New York. | 40 43 | 74 01 | 1825 | March. | 73 27.0 | ---- |
| Do. | 40 42.6 | 74 00.5 | 1831 | Apr. 19. | 73 00 | ---- |

*intensities in the United States and adjacent regions.—Continued.*

NEW JERSEY—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 13.50 | ° 72.21 | 4.066 | 13.31 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | 72.25 | ---- | ---- | Do. | Am. Phil. Soc., 1846, Vol. IX. |
| 13.54 | } 72.31 | } 4.037 | } 13.29 | Do. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.46 | | | | Do. | Do. |
| 13.46 | | | | Do. | Do. |
| 13.46 | | | | Do. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 72.17 | ---- | ---- | Do. | Am. Phil. Soc., 1846, Vol. IX. |
| ---- | ---- | ---- | ---- | Do. | Do. |

NEW MEXICO.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 11.70 | ---- | 6.21 | ---- | W. H. Emory. | U. S. & Mex. Bound. Sur., Am. Acad. Sc., Vol. VI, 1856. |
| 11.45 | ---- | 6.10 | ---- | Do. | Do. |
| 11.92 | ---- | 6.15 | ---- | Do. | Do. |
| 11.73 | ---- | 6.07 | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| 12.54 | ---- | 5.76 | ---- | J. C. Ives and A. W. Whipple. | C. S. Rpt., 1856, p. 222. |
| 12.56 | ---- | 5.59 | ---- | Do. | Do. |
| 12.49 | ---- | 5.87 | ---- | Do. | Do. |
| 12.55 | ---- | 5.82 | ---- | Do. | Do. |
| 12.49 | ---- | 5.80 | ---- | Do. | Do. |
| 12.56 | ---- | 5.76 | ---- | Do. | Do. |
| 11.64 | ---- | ---- | ---- | Do. | Do. |
| 12.51 | ---- | 5.84 | ---- | Do. | Do. |
| 12.56 | ---- | 5.75 | ---- | Do. | Do. |
| 12.51 | ---- | 5.81 | ---- | Do. | Do. |

NEW YORK.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 13.45 | 71.88 | 4.101 | 13.19 | J. Locke. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | } 72.20 | 4.012 | 13.12 { | J. S. Ruth. | Do. |
| 13.34 | | | | C. A. Schott. | Do. |
| 13.62 | | | | E. Sabine. | Sill. J., 1838 & 1842. E. Loomis; Brit. Asso. Rpt., Vol. VI, 1838; C. S. Rpt., 1861. |
| ---- | | | | J. Franklin. | Sill. J., 1838 & 1842. E. Loomis. |
| ---- | | | | Joslyn. | Sill. J., Vol. XXII, 1832. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

NEW YORK—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| New York. | 40 43 | 74 01 | 1833 | April. | {73 49.3<br>72 14} | ---- |
| New York, Columbia College (old site). | 40 42.6 | 74 00.5 | 1834 | Aug. | 72 51.7 | ---- |
| Do. | 40 42.6 | 74 00.5 | 1835 | ---- | ---- | 3.973 |
| Do. | 40 43 | 74 01 | 1839 | Sept. | 72 52.2 | 4.012 |
| Do. | 40 42.6 | 74 00.5 | 1841 | Apr. 19. | 72 41 | 4.022 |
| New York. | 40 46.1 | 76 56.5 | 1841 | Dec. | 72 39.6 | 4.014 |
| New York, Columbia College (old site). | 40 42.6 | 74 00.5 | 1842 | ---- | 72 37.2 | 4.030 |
| Do. | 40 42.6 | 74 00.5 | 1844 | Apr. 27. | 72 42.6 | 4.007 |
| Do. | 40 42.6 | 74 00.5 | 1844 | Aug. 8–31. | 72 37.8 | 4.071 |
| New York. | 40 43 | 74 01 | 1844 | ---- | 72 28.9 | ---- |
| New York, Columbia College (old site). | 40 42.6 | 74 00.5 | 1845 | Sept. 4. | 72 40.6 | ---- |
| Flatbush, Mount Prospect, Brooklyn. | 40 40.3 | 73 58.0 | 1846 | May 6. | 72 27.6 | 4.054 |
| New York. | 40 41 | 74 02 | 1846 | Nov. | 72 39.3 | ---- |
| New York, Rutherfurd's observatory. | 40 43.9 | 73 59.2 | 1853 | May 19. | 72 55.6 | ---- |
| New York, Governor's Island. | 40 41.5 | 74 01.1 | 1855 | Aug. 7. | 72 46.3 | 3.926 |
| New York, Bedloe's Island. | 40 41.4 | 74 02.7 | 1855 | Aug. 8. | 72 59.2 | 3.920 |
| New York, receiving reservoir, Central Park. | 40 46.7 | 73 58.2 | 1855 | Aug. 10. | 72 44.4 | 3.938 |
| Flatbush, Mount Prospect, Brooklyn. | 40 40.3 | 73 58.0 | 1860 | Sept. 20–22. | 72 40.8 | 4.052 |
| New York, Central Park. | 40 46.2 | 73 58.2 | 1872 | Nov. 1–4. | 72 35.8 | 3.982 |
| New York, new asylum, New Harlem. | 40 49 | 73 58 | 1841 | Apr. 20. | 72 21 | 4.099 |
| New York, Bloomingdale Asylum, Manhattanville. | 40 50.3 | 73 56.7 | 1841 | Apr. 20. | 72 39.6 | 4.019 |
| Do. | 40 50.3 | 73 56.7 | 1842 | Sept. 26. | 72 35.6 | 4.008 |
| Do. | 40 50.3 | 73 56.7 | 1844 | Apr. 26. | 72 41.7 | 4.005 |
| Do. | 40 50.3 | 73 56.7 | 1844 | Sept. 3. | 72 49.5 | 4.008 |
| Do. | 40 50.3 | 73 56.7 | 1846 | Apr. 27, 30. | 72 39.0 | 4.009 |
| Patchogue, west of Ocean House. | 40 44.9 | 73 01.5 | 1875 | July 30–Aug. 5. | 72 45.4 | 3.968 |
| Legget, geodetic station. | 40 48.9 | 73 53.5 | 1847 | Oct. 15–20. | 72 52.7 | 3.976 |
| West Hills, about 200 metres north and east of geodetic station. | 40 48.9 | 73 25.5 | 1865 | Aug. 10–21. | 72 56.8 | 3.930 |
| Ruland. | 40 50.7 | 73 02.0 | 1865 | May 25–June 6. | 72 54.9 | 3.945 |
| Oyster Bay. | 40 52.3 | 73 31.6 | 1844 | Sept. 16, 17. | 72 58.5 | 3.894 |
| New Rochelle, south of Neptune House. | 40 52.5 | 73 47.3 | 1844 | Sept. 10. | 72 44.0 | 3.845 |
| Lloyd Harbor, Huntington. | 40 55.6 | 73 25.1 | 1844 | Sept. 15. | 72 50.6 | 3.857 |

***intensities in the United States and adjacent regions.**—Continued.*

NEW YORK—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| ---- | | | | Back. | Sill. J., 1838 & 1842. E. Loomis. In Encyc. Brit., 7th ed., 1842, $\theta = 73° 14'$. |
| ---- | | | | A. D. Bache. | Sill. J., 1838 & 1842. E. Loomis. |
| 13.48 | | | | A. D. Bache and E. H. Courtenay. | C. S. Rpt., 1861, App. 22. |
| 13.52 | | | | E. Loomis. | Sill. J., Vol. XXXIX, 1840. The total intensities for Phila. = 13.41 for conversion of relative into absolute value. |
| 13.51 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | | | | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.49 | 71.98 | 4.060 | 13.12 | J. Locke. | Sill. J., Vol. IV, 1847. |
| 13.48 | | | | Do. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.64 | | | | J. Renwick. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| ---- | | | | J. Renwick. | C. & G. S. Rpt., 1881, App. 9. |
| 13.45 | | | | J. Locke. | Do. |
| ---- | | | | Officer of corvette Nordstiernen. | Letter of Prof. Hansteen, Oct. 15, 1854. |
| ---- | | | | E. K. Kane and A. Sonntag. | Mag. Obsns. Arctic Seas. Smithsonian Cont's to Know. Wash., 1858. |
| 13.25 | | | | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.40 | | | | Do. | Do. |
| 13.27 | | | | Do. | Do. |
| 13.61 | | | | Do. | Do. |
| 13.31 | | | | A. H. Scott and E. Goodfellow. | Do. |
| 13.52 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.48 | | | | Do. | Do. |
| 13.426 | 71.94 | 4.05 | 13.06 | J. H. Lefroy. | Diary Mag. Sur. Canada. London, 1883. θ, H & F obs'd. |
| 13.47 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.57 | | | | J. Renwick and J. H. Lefroy. | C. & G. S. Rpt., 1881, App. 9. |
| 13.44 | | | | J. Locke. | Do. |
| 13.39 | 72.20 | 4.003 | 13.10 | J. M. Poole. | Do. |
| 13.51 | 72.18 | 4.060 | 13.27 | R. H. Fauntleroy. | Do. |
| 13.40 | 72.18 | 4.019 | 13.13 | E. Goodfellow and A. D. Bache. | Do. |
| 13.43 | 72.13 | 4.034 | 13.15 | E. Goodfellow and A. D. Bache. | Do. |
| 13.30 | 72.29 | 3.953 | 13.00 | J. Renwick. | Do. |
| 12.95 | 72.04 | (3.904) | (12.66) | Do. | Do. |
| 13.08 | 72.15 | (3.916) | (12.78) | Do. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

NEW YORK—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| East Hampton, on top of steep bank. | 40 57.5 | 72 11.5 | 1875 | Aug. 23, 24. | 72 47.3 | 3.986 |
| Port Chester, Sawpit's steamboat landing. | 40 59.6 | 73 39.7 | 1844 | Sept. 11. | 72 53.4 | ---- |
| Sag Harbor, Mulford's Hill. | 40 59.9 | 72 17.4 | 1860 | Sept. 4, 5. | 73 20.9 | 3.903 |
| Greenport. | 41 06 | 72 21 | 1845 | Aug. 19. | 72 57.9 | 3.850 |
| Carpenter's Point, Port Jervis. | 41 21.4 | 74 41.7 | 1873 | June 21, 23. | 73 14.3 | 3.897 |
| West Point, United States Military Academy. | 41 23.5 | 73 57.3 | 1833 | April. | 73 25.8 | ---- |
| Do. | 41 23.5 | 73 57.3 | 1834 | May, June, July. | 73 37.2 | ---- |
| West Point, United States Military Academy, rear of Courtenay's house. | 41 23.5 | 73 57.3 | 1835 | ---- | ---- | 3.866 |
| West Point, bank near steamboat landing. | 41 24 | 73 58 | 1839 | Sept. | 73 27.4 | ---- |
| West Point. | 41 23.5 | 73 58 | 1840 | Aug. | 73 20.1 | ---- |
| West Point, in Bartlett's garden. | 41 24 | 73 58 | 1842 | Oct. 19, 20. | 73 31.5 | 3.886 |
| West Point. | 41 23.4 | 73 57 | 1843 | July. | 73 12.2 | 4.033 |
| Cold Spring, on bluff west of railroad and near depot. | 41 25.0 | 73 57.6 | 1855 | Sept. 1. | 73 54.8 | 3.790 |
| Poughkeepsie. | 41 42 | 73 56 | 1844 | June 13. | 73 57.7 | 3.733 |
| Opposite Poughkeepsie. | 41 42 | 73 57 | 1844 | June 13. | 74 12.3 | 3.728 |
| Owego. | 42 08 | 76 17 | 1841 | Aug. | 74 13.9 | 3.614 |
| Belvedere. | 42 13 | 78 06 | 1841 | Aug. | 74 09.5 | 3.669 |
| Mayville, grounds of Public School. | 42 16 | 79 40 | 1874 | Aug. 4. | 74 05.0 | 3.733 |
| Ellicottsville. | 42 18.1 | 78 44 | 1841 | Aug. | 74 17.8 | 3.726 |
| Bath. | 42 20.8 | 77 21 | 1841 | Aug. | 74 27.5 | 3.677 |
| Bath, public park, opposite post-office. | 42 20.8 | 77 21.3 | 1862 | Aug. 11. | 74 26.2 | 3.671 |
| Bath, field belonging to Judge Runsey. | 42 21 | 77 21 | 1874 | July 24, 25. | 74 15.5 | 3.724 |
| Oxford, on hill about ¼ of a mile north of depot. | 42 26.5 | 75 40.5 | 1874 | June 4. | 74 05.8 | 3.726 |
| Ithaca, grounds of Cornell University. | 42 27.5 | 76 33.0 | 1874 | June 13. | 74 14.7 | 3.664 |
| Dunkirk. | 42 29.3 | 79 23 | 1841 | Aug. | 74 17.2 | 3.621 |
| Albany, side of hill between Orange and Patroon streets. | 42 39 | 73 45 | 1833 | April. | 74 51.1 | ---- |
| Albany. | 42 39 | 73 45 | 1834 | Aug. | 74 40.1 | ---- |
| Albany, yard of Franklin House, State street. | 42 39 | 73 43 | 1835 | ---- | ---- | 3.578 |
| Albany, northwest of the Capitol. | 42 39 | 73 45 | 1839 | Sept. | 74 51.3 | ---- |
| Albany, near Orphan Asylum, ½ mile west of Capitol. | 42 39.1 | 73 44.8 | 1841 | Aug. | 74 39.9 | ---- |
| Albany. | 42 39 | 73 45 | 1841 | ---- | 74 40.1 | ---- |
| Albany, side of hill between Orange and Patroon streets. | 42 39 | 73 45 | 1842 | Oct. 21. | 74 44.6 | 3.581 |
| Albany. | 42 39 | 73 45 | 1844 | June 14. | 74 40.2 | 3.582 |
| Greenbush, opposite Albany. | 42 38 | 73 44 | 1844 | June 14. | 74 43.1 | 3.578 |
| Greenbush, near Second street. | 42 37.5 | 73 44.3 | 1855 | Aug. 31. | 75 11.1 | 3.587 |
| Albany. | 42 40 | 73 45 | 1856 | Sept. | 74 56 | 3.575 |
| Albany, Dudley Observatory. | 42 39.8 | 73 45.0 | 1858 | May 13–19. | 74 55.6 | 3.586 |
| Do. | 42 39.8 | 73 45.1 | 1879 | Oct. 21–24. | 74 18.9 | 3.645 |

*intensities in the United States and adjacent regions.— Continued.*

NEW YORK—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | F .0 | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| 13.47 | 72.23 | 4.022 | 13.18 | J. M. Poole. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 72.20 | ---- | ---- | J. Renwick. | Do. |
| 13.62 | 72.55 | 4.020 | 13.41 | C. A. Schott. | Do. |
| 13.14 | 72.27 | 3.917 | 12.86 | J. Renwick. | Do. |
| 13.51 | 72.62 | 3.944 | 13.20 | E. Smith. | Do. |
| ---- | | | | E. H. Courtenay and J. Henry. | Sill. J., Vol. XXXIV, 1838. |
| ---- | | | | E. H. Courtenay. | Do. |
| 13.71 | 72.71 | 4.009 | 13.49 | A. D. Bache and E. H. Courtenay. | Am. Phil. Soc., Vol. V, 1837, & C. S. Rpt., 1861, App. 22. |
| ---- | | | | E. Loomis. | Sill. J., Vol. XXXIX, 1840. |
| ---- | | | | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| 13.702 | | | | J. H. Lefroy and Bartlett. | Diary Mag. Sur. Canada, London, 1883. |
| ---- | | | | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.68 | 73.12 | 3.926 | 13.52 | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.51 | 73.39 | 3.788 | 13.25 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.70 | | | | Do. | Do. |
| ---- | 73.54 | 3.656 | 12.90 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| ---- | 73.47 | 3.711 | 13.04 | Do. | Do. |
| ---- | 73.49 | 3.775 | 13.28 | F. E. Hilgard and W. Diehl. | C. & G. S. Rpt., 1882, App. 14. Nat. Acad. Ser. |
| ---- | 73.61 | 3.768 | 13.35 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| ---- | | | | Do. | Do. |
| 13.68 | 73.70 | 3.754 | 13.38 | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | F. E. Hilgard and W. Diehl. | C. & G. S. Rpt., 1882, App. 14. Nat. Acad. Ser. |
| 13.60 | 73.51 | 3.768 | 13.27 | T. C. Hilgard. | C. & G. S. Rpt., 1881, App. 9. |
| 13.49 | 73.65 | 3.706 | 13.17 | Do. | Do. |
| ---- | 73.60 | 3.663 | 12.97 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| ---- | | | | J. Henry and T. J. Cram. | Sill. J., Vol. XXXIV, 1838. E. Loomis. |
| ---- | | | | A. D. Bache. | Do. |
| 13.53 | | | | A. D. Bache and E. H. Courtenay. | C. S. Rpt., 1861, App. 22. |
| ---- | | | | E. Loomis. | Sill. J., 1840. |
| ---- | | | | J. N. Nicollet. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | | | | A. D. Bache. | Phil. Trans. R. S., 1846. |
| 13.610 | 74.03 | 3.673 | 13.35 | J. H. Lefroy. | Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883. |
| 13.55 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.58 | | | | Do. | Do. |
| 14.03 | | | | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 14.00 | | | | K. Friesach. | K. K. Acad. d. Wiss. Vienna, Vol. XXIX, 1858. |
| 13.79 | | | | G. W. Dean. | C. & G. S. Rpt., 1881, App. 9. |
| 13.48 | | | | J. B. Baylor. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

NEW YORK—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Sherburne, rear of Newton's barn. | 42 41.2 | 75 33.0 | 1875 | Sept. 2, 3, 4. | 74 15.1 | 3.726 |
| Troy. | 42 43.7 | 73 40.7 | 1843 | Aug. | 74 47.9 | 3.575 |
| Otsego, | 42 46.9 | 74 42.2 | 1882 | Aug. 16, 17. | 73 55.4 | 3.673 |
| Schenectady, south of village. | 42 48 | 73 55 | 1839 | Sept. | 74 36.1 | ---- |
| Do. | 42 48 | 73 57 | 1843 | July. | 74 54.8 | 3.502 |
| Geneva. | 42 53 | 77 02 | 1843 | July. | 74 33.2 | 3.635 |
| Buffalo, east of the American House. | 42 53 | 78 55 | 1839 | Aug. | 74 40.8 | ---- |
| Buffalo. | 42 53 | 78 55 | 1844 | June 23. | 74 36.5 | 3.663 |
| Buffalo, behind High School, Fourth and Delaware streets. | 42 55 | 78 54 | 1845 | Oct. 20. | 74 37.8 | ---- |
| Buffalo. | 42 53.0 | 78 53.0 | 1859 | June 11. | 74 47 | 3.608 |
| Buffalo, at Fort Porter. | 42 55 | 78 54 | 1872 | June 13, 14. | 74 43 | 3.644 |
| Do. | 42 55 | 78 54 | 1873 | June 3–6. | 74 29 | 3.667 |
| Fenner. | 42 57.4 | 75 44.6 | 1882 | Oct. 5, 6. | 74 18.4 | 3.646 |
| Howlett. | 43 00.0 | 76 17.4 | 1883 | Aug. 30, 31; Sept. 1, 3. | 74 17.5 | 3.625 |
| Syracuse, northeast of village. | 43 01 | 76 09 | 1839 | Sept. | 74 50.9 | ---- |
| Syracuse. | 43 00 | 76 09.3 | 1843 | July. | 74 51.2 | 3.556 |
| Niagara Falls, New York side east of town, near Cataract Hotel. | 43 02 | 79 04 | 1841 | Sept. | 74 52.4 | ---- |
| Niagara Falls. | 43 04 | 79 04 | 1843 | Aug. | 74 51.0 | 3.565 |
| Niagara Falls. | 43 03 | 79 04 | 1856 | Sept. 12. | ---- | 3.600 |
| Niagara Falls, in lot of Mr. Holley. | 43 04 | 79 04 | 1874 | July 31. | 74 37.7 | 3.646 |
| Clyde. | 43 03.1 | 76 51.8 | 1883 | Sept. 20, 21, 22. | 74 31.8 | 3.580 |
| Clinton, Hamilton College. | 43 03.2 | 75 24.2 | 1874 | Oct. 25. | 74 37.5 | 3.635 |
| Utica, northeast of village. | 43 07 | 75 13 | 1839 | Sept. | 74 57.2 | ---- |
| Utica. | 43 05 | 75 14 | 1843 | July. | 74 50.3 | 3.541 |
| Do. | 43 07 | 75 13 | 1844 | June 16. | 74 48.8 | 3.582 |
| Rochester, corner Mill street, garden behind Mansion House. | 43 10 | 77 41 | 1843 | Mar. 14. | 74 41.0 | ---- |
| Rochester. | 43 07 | 77 39 | 1843 | Aug. | 74 43.5 | 3.560 |
| Do. | 43 08 | 77 41 | 1844 | June 17. | 74 38.8 | 3.615 |
| Rochester College grounds. | 43 08 | 77 40 | 1874 | July 29. | 74 38.5 | 3.632 |
| Lockport. | 43 11 | 78 46 | 1844 | June 18. | 74 44.2 | 3.599 |
| Fort Niagara, near flagstaff. | 43 15 | 79 04 | 1859 | June 15. | 74 51 | 3.584 |
| Charlotte, near light-house. | 43 15 | 77 37 | 1859 | June 18. | 75 12 | 3.561 |
| Charlotte, Latty street, near Broadway. | 43 15 | 77 37 | 1872 | June 7–10. | 74 58 | 3.619 |
| Charlotte, in rear of Methodist church. | 43 15 | 77 37 | 1873 | May 29, 30, 31. | 74 50 | 3.633 |
| Loomis. | 43 21.3 | 76 17.2 | 1882 | Nov. 10, 11. | 74 47.7 | 3.518 |

*intensities in the United States and adjacent regions.—Continued.*

NEW YORK—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| 13.73 | 73.83 | 3.762 | 13.51 | J. M. Poole. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 74.11 | 3.627 | 13.25 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.264 | 73.74 | 3.682 | 13.15 | J. B. Baylor and C. O. Boutelle. | MS. in C. & G. S. Office. |
| ---- | 74.07 | 3.554 | 12.95 | E. Loomis. | Sill. J., 1840. |
| ---- | | | | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| ---- | 73.96 | 3.687 | 13.34 | Do. | Do. |
| ---- | | | | E. Loomis. | Sill. J., 1840. |
| 13.80 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.694 | 73.96 | 3.715 | 13.45 | J. H. Lefroy. | Diary Mag. Sur. Canada. Genl. Sir J. H. Lefroy, London, 1883. |
| 13.743 | | | | W. P. Smith. | U. S. Lake Sur. Rpt., 1859. |
| 13.823 | | | | A. N. Lee. | U. S. Lake Sur. Rpt., 1873. |
| 13.707 | | | | Do. | Do. |
| 13.479 | 74.14 | 3.655 | 13.37 | J. B. Baylor and C. O. Boutelle. | MS. in C. & G. S. Office. |
| 13.389 | 74.18 | 3.630 | 13.32 | Do. | Do. |
| ---- | 74.15 | 3.608 | 13.21 | E. Loomis. | Sill. J., Vol. XXXIX, 1840. |
| ---- | | | | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| ---- | | | | J. N. Nicollet. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | 74.06 | 3.690 | 13.44 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 14.32 | | | | K. Friesach. | K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858. |
| ---- | | | | F. E. Hilgard and W. Diehl. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| 13.421 | 74.43 | 3.585 | 13.36 | J. B. Baylor and C. O. Boutelle. | MS. in C. & G. S. Office. |
| 13.71 | 74.03 | 3.676 | 13.36 | T. C. Hilgard. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | E. Loomis. | Sill. J., 1840. |
| ---- | 74.18 | 3.617 | 13.27 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.68 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.670 | | | | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| ---- | | | | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.66 | 74.01 | 3.653 | 13.26 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | | | | F. E. Hilgard and W. Diehl. | C. & G. S. Rpt., 1882, App. 14 (Nat. Acad. Ser). |
| 13.68 | 74.05 | 3.657 | 13.31 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.716 | 74.05 | 3.706 | 13.49 | W. P. Smith. | U. S. Lake Sur., Capt. G. G. Meade, 1859. |
| 13.942 | | | | Do. | Do. |
| 13.920 | 74.31 | 3.678 | 13.60 | A. N. Lee. | U. S. Lake Sur. Gen'l C. B. Comstock, 1873. |
| 13.886 | | | | Do. | Do. |
| 13.414 | 74.63 | 3.526 | 13.30 | J. B. Baylor and C. O. Boutelle. | MS. in C. & G. S. Office. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

NEW YORK—Continued.

| Name of station. | Latitude. φ. | West longitude | Year. | Month. | Dip. θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Pen Mount. | 43 22.8 | 75 15.6 | 1882 | Aug. 21, 22. | 74 31.4 | 3.606 |
| Prospect. | 43 25.9 | 73 45.4 | 1882 | Aug. 7, 8, 9. | 74 43.5 | 3.525 |
| Oswego, west of village. | 43 26 | 76 36 | 1839 | Aug. | 75 11.3 | ---- |
| Oswego, Woodruff's garden, near Baptist church. | 43 26 | 76 36 | 1841 | Sept. | 75 08.1 | ---- |
| Oswego. | 43 26 | 76 35 | 1843 | Aug. | 75 07.1 | 3.467 |
| Pierrepont Manor, about one-half mile southwest of village. | 43 44.5 | 76 04.0 | 1874 | Oct. 20. | 75 25.1 | 3.470 |
| Mannsville. | 43 42.9 | 76 03.2 | 1884 | June 6, 7, 9. | ---- | 3.468 |
| Sackett's Harbor, near barracks. | 43 57 | 76 07 | 1859 | June 22. | 75 44 | 3.403 |
| Sackett's Harbor, at barracks. | 43 57 | 76 07 | 1872 | June 5. | 75 27 | 3.482 |
| Do. | 43 57 | 76 07 | 1873 | May 26, 27. | 75 24 | 3.471 |
| Potsdam, about one-half mile southwest of depot. | 44 37.0 | 75 00.0 | 1874 | Oct. 15. | 76 03.3 | 3.268 |
| Rouse's Point. | 45 00 | 73 22 | 1845 | ---- | 76 40.7 | ---- |
| Rouse's Point, near Major Graham's monument. | 45 00.4 | 73 21.2 | 1879 | Oct. 1. | 76 18.2 | 3.270 |

NORTH CAROLINA.

| Name of station. | Latitude. φ. | West longitude | Year. | Month. | Dip. θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Fort Johnson, Smithville. | 33 55.0 | 78 00.9 | 1859 | May 3–7. | 66 17.1 | 5.260 |
| Fort Johnson, near flag-staff. | 33 55.0 | 78 00.9 | 1874 | Dec. 27–30. | 66 00.6 | 5.297 |
| Wilmington, near Dr. Drune's house. | 34 14.0 | 77 56.6 | 1854 | June 3, 5. | 66 47.2 | 5.195 |
| Beaufort. | 34 43 | 76 40 | 1880 | Jan. 14, 15. | 66 49.8 | 5.055 |
| Portsmouth Island, Northeast Base. | 35 04.0 | 76 03.2 | 1871 | Apr. 1–5. | 67 13.6 | 5.006 |
| New Berne, National Cemetery. | 35 07.4 | 77 03.3 | 1874 | Dec. 21–24. | 67 30.6 | 4.959 |
| Charlotte, corner Church and Sixth streets. | 35 14 | 80 46 | 1873 | Aug. 1. | 67 07.5 | 5.089 |
| Asheville. | 35 36 | 82 30 | 1833 | Sept. | 67 25 | ---- |
| Asheville, grounds of Eagle Hotel. | 35 35 | 82 30 | 1873 | Aug. 7. | 67 26.7 | 5.078 |
| Salisbury. | 35 40.4 | 80 20 | 1873 | July 30. | 67 46.0 | 5.021 |
| Raleigh, grounds of Capitol. | 35 46.8 | 78 38.1 | 1854 | Jan. 7–16. | 68 11.6 | 4.963 |
| Morganton, opposite Episcopal Church. | 35 47.4 | 81 30 | 1873 | Aug. 5. | 67 15.3 | 5.067 |
| Bodie's Island, near Midgett's house. | 35 47.5 | 75 32.0 | 1846 | Dec. 25–28. | 68 18.1 | 4.755 |
| Warm Spring. | 35 50 | 82 48 | 1833 | Sept. | 67 39 | ---- |
| Sand Island. | 35 50.4 | 75 40.1 | 1876 | Jan. 22; Feb. 7. | 68 05.4 | 4.893 |
| Greensboro', Gaston street, above Green. | 36 03.5 | 79 40 | 1873 | July 28. | 68 35.3 | 4.901 |
| Shellbank. | 36 03.6 | 75 44.5 | 1847 | Mar. 26; Apr. 9. | 68 37.8 | 4.714 |
| Stevenson's Point. | 36 06.3 | 76 11.4 | 1847 | Jan. 30; Feb. 15. | 68 54.5 | 4.660 |

***intensities in the United States and adjacent regions.—Continued.***

NEW YORK—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 13.514 | ° 74.34 | 3.614 | 13.39 | J. B. Baylor & C. O. Boutelle. | MS. in C. & G. S. Office. |
| 13.380 | 74.54 | 3.533 | 13.25 | Do. | Do. |
| ---- | | | | E. Loomis. | Sill. J., Vol. XXXIX, 1840. The total intensity for Phila. = 13.41 for conversion of relative into absolute value. |
| ---- | 74.46 | 3.519 | 13.14 | J. N. Nicollet. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | | | | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.78 | 74.83 | 3.490 | 13.34 | T. C. Hilgard. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | J. B. Boutelle. | MS. in C. & G. S. Office. |
| 13.809 | | | | W. P. Smith. | U. S. Lake Sur., Capt. G. G. Meade, 1859. |
| 13.847 | 74.83 | 3.525 | 13.47 | A. N. Lee. | U. S. Lake Sur., Gen'l C. B. Comstock, 1873. |
| 13.770 | | | | Do. | Do. |
| 13.56 | 75.47 | 3.309 | 13.19 | T. C. Hilgard. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 75.95 | 3.290 | 13.55 | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| 13.81 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 19. |

NORTH CAROLINA.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 13.08 | 65.80 | 5.310 | 12.95 | G. W. Dean. | C. & G. S. Rpt., 1881, App. 9. |
| 13.03 | | | | J. B. Baylor. | Do. |
| 13.18 | 66.40 | 5.237 | 13.08 | G. W. Dean. | Do. |
| 12.85 | 66.66 | 5.065 | 12.78 | J. B. Baylor. | Do. |
| 12.93 | 66.89 | 5.035 | 12.83 | A. T. Mosman. | Do. |
| 12.96 | 67.22 | 4.979 | 12.86 | J. B. Baylor. | Do. |
| ---- | 66.82 | 5.112 | 12.99 | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser. |
| ---- | 67.06 | 5.101 | 13.09 | J. N. Nicollet. | C. S. Rpt., 1864, App. 19. |
| ---- | | | | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser. |
| ---- | 67.46 | 5.044 | 13.16 | Do. | Do. |
| 13.36 | 67.80 | 5.00 | 13.23 | G. W. Dean. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 66.95 | 5.090 | 13.00 | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser. |
| 12.86 | 67.96 | 4.79 | 12.77 | C. O. Boutelle. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 67.23 | ---- | ---- | J. N. Nicollet. | C. S. Rpt., 1864, App. 19. |
| 13.11 | 67.82 | 4.910 | 13.01 | E. Smith. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 68.28 | 4.924 | 13.31 | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser. |
| 12.94 | 68.29 | 4.75 | 12.84 | C. O. Boutelle and G. Davidson. | C. & G. S. Rpt., 1881, App. 9. |
| 12.95 | 68.57 | 4.69 | 12.84 | C. O. Boutelle. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

OHIO.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Cincinnati. | 39 06 | 84 26 | 1838 | Mar. 20. | 70 28.1 | ---- |
| Do. | 39 06 | 84 27 | 1838 | ---- | 70 46 | ---- |
| Do. | 39 06 | 84 27 | 1840 | Aug. 18. | 70 27.4 | ---- |
| | | | | Sept. 24. | 70 29.2 | |
| Do. | 39 06 | 84 27 | 1841 | May 8. | 70 26.2 | ---- |
| Cincinnati, Longworth's Garden, east side of city. | 39 06 | 84 27 | 1841 | Oct. | 70 27.7 | ---- |
| Cincinnati. | 39 06 | 84 27 | 1842 | Mar. 31. | 70 25.4 | ---- |
| Do. | 39 06 | 84 27 | 1843 | Aug. 21. | 70 25.5 | ---- |
| Do. | 39 06 | 84 27 | 1844 | Mar. 21. | 70 28 | 4.548 |
| | | | | July 4. | 70 25 | |
| Do. | 39 06 | 84 27 | 1845 | Apr. 23. | 70 26 | 4.548 |
| Cincinnati, Longworth's Garden. | 39 06 | 84 27 | 1849 | June 5. | 70 28.8 | ---- |
| Cincinnati Observatory, on Mount Lookout. | 39 08.6 | 84 25.4 | 1880 | Nov. 29, 30. | 70 24.7 | 4.488 |
| Athens, west of College buildings. | 39 19.8 | 82 02 | 1880 | Dec. 3, 4. | 70 58.7 | 4.390 |
| Mason. | 39 22 | 84 13 | 1840 | Aug. 25. | 70 54.2 | 4.442 |
| Hamilton. | 39 23 | 84 32 | 1840 | Aug. 20. | 70 58 | 4.448 |
| Marietta. | 39 25 | 81 28 | 1845 | ---- | 71 22.3 | ---- |
| Lebanon. | 39 26 | 84 06 | 1840 | Aug. 24. | 71 02.7 | 4.419 |
| Oxford. | 39 30 | 84 38 | 1845 | ---- | 71 10.0 | ---- |
| Carrollton. | 39 38 | 84 09 | 1840 | ---- | 71 10.0 | ---- |
| Dayton. | 39 45 | 84 09 | 1838 | Mar. 26. | 71 22.7 | 4.369 |
| Do. | 39 44 | 84 09 | 1840 | Aug. 21. | 71 22.0 | 4.339 |
| Springfield. | 39 54 | 83 50 | 1838 | Mar. 29. | 71 27.4 | 4.329 |
| Columbus. | 39 57 | 83 01 | 1838 | Apr. 2. | 71 04.9 | 4.408 |
| Columbus, east of new State House yard. | 39 57.7 | 82 59.5 | 1841 | Oct. | 71 03.4 | ---- |
| Columbus. | 39 57 | 83 01 | 1845 | ---- | 71 04.3 | ---- |
| Columbus, Capitol Square. | 39 57.7 | 82 59.7 | 1871 | Oct. 3–9. | 71 09.8 | 4.369 |
| Columbus, grounds of Blind Asylum. | 39 57 | 82 59 | 1874 | Aug. 19. | 70 59.7 | 4.359 |
| Hebron, north of Stage House. | 39 59 | 82 29 | 1841 | Oct. | 71 10.1 | ---- |
| Urbana. | 40 03 | 83 42 | 1838 | Mar. 30. | 71 39.7 | 4.347 |
| Piqua. | 40 06 | 84 13 | 1840 | Aug. 22. | 71 35.8 | 4.301 |
| Frazeysburg, near canal lock No. 16. | 40 09 | 82 08 | 1841 | Oct. | 71 48.7 | ---- |
| Tuscarawas, field of Blinkensdorfer. | 40 24.2 | 81 50 | 1874 | Aug. 17. | 72 08.5 | 4.146 |
| Steubenville. | 40 25 | 80 39 | 1840 | Aug. | 72 32.8 | 3.947 |
| St. Mary's. | 40 32 | 84 19 | 1845 | ---- | 72 00.3 | ---- |

***intensities in the United States and adjacent regions.**—Continued.*

OHIO.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| ---- | | | | J. Locke. | Am. Phil. Soc., Phila., 1846, Art. XI; Dr. J. Locke's paper for 1884. |
| ---- | | | | Do. | Sill. J., Vol. XXXIV, 1838. (Loomis collection.) |
| ---- | | | | Do. | Sill. J., 1840, E. Loomis, and Am. Phil. Soc., Vol. VII, 1840, and 1846, Art. XI. |
| ---- | | | | Do. | Am. Phil. Soc., Vol. IX, 1846. |
| ---- | 69.9 | 4.58 | 13.33 | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | | | | J. Locke. | Sill. J., Vol. IV, 1847. |
| ---- | | | | Do. | Am. Phil. Soc., 1846, Art. XI. |
| 13.59 | | | | Do. | Am. Phil. Soc., 1846, Art. XI, and for H. and F., Phil. Trans. R. S., 1846; E. Sabine. |
| ---- | | | | Do. | Smithsonian Cont's to Know., Vol. 3, 1852. |
| 13.548 | | | | J. H. Lefroy. | Diary Mag. Sur., Canada, London, 1883. |
| 13.39 | 70.19 | 4.496 | 13.27 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.47 | 70.77 | 4.405 | 13.38 | Do. | Do. |
| 13.58 | 70.38 | 4.48 | 13.35 | J. Locke. | Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844. |
| 13.64 | 70.45 | 4.49 | 15.42 | Do. | Do. |
| 13.62 | 70.86 | 4.41 | 13.46 | Do. | Phil. Trans. R. S., 1846. |
| 13.60 | 70.51 | 4.46 | 13.37 | Do. | Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844. |
| 13.66 | 70.66 | 4.47 | 13.50 | Do. | Phil. Trans. R. S., 1846. |
| 13.62 | 70.64 | 4.44 | 13.39 | Do. | Do. |
| 13.69 | 70.82 | 4.39 | 13.36 | Do. | Sill. J., 1838, E. Loomis, and Trans. Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844. |
| 13.58 | | | | Do. | Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844. |
| 13.61 | 70.91 | 4.36 | 13.34 | Do. | Do. |
| 13.60 | | | | Do. | Sill. J., 1838, E. Loomis, and Trans. Am. Phil. Soc., 1846, Art. XI. |
| ---- | 70.56 | 4.422 | 13.29 | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | | | | J. Locke. | Phil. Trans. R. S., 1846. |
| 13.53 | | | | A. T. Mosman. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | F. E. Hilgard and W. Diehl. | C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser. |
| ---- | 70.65 | ---- | ---- | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843; Prof. E. Loomis. |
| 13.81 | 71.11 | 4.38 | 13.54 | J. Locke. | Sill. J., 1838, E. Loomis, and Trans. Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844. |
| 13.62 | 71.08 | 4.34 | 13.39 | Do. | Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844. |
| ---- | 71.29 | ---- | ---- | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843; Prof. E. Loomis. |
| ---- | 71.69 | 4.188 | 13.33 | F. E. Hilgard and W. Diehl. | C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser. |
| ---- | 72.03 | (3.99) | (12.93) | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.66 | 71.49 | 4.28 | 13.47 | J. Locke. | Phil. Trans. R. S., 1846. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

OHIO—Continued.

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Dover, near canal lock, 2 miles north of town. | 40 33 | 81 30 | 1841 | Oct. | 72 19.2 | ---- |
| Wellsville, Ohio River. | 40 38 | 80 44 | 1844 | June 26. | 72 35.3 | 4.060 |
| Forest, woods south of town. | 40 50 | 83 28 | 1874 | Aug. 21. | 72 20.7 | 4.108 |
| Fulton, near canal lock. | 40 55 | 81 38 | 1841 | Oct. | 72 38.9 | ---- |
| Clinton, near canal lock. | 40 58 | 81 40 | 1841 | Oct. | 72 44.0 | ---- |
| Tallmadge. | 41 06 | 81 27 | 1841 | Apr.<br>Oct. | 72 55.2<br>72 51.5 | ---- |
| Hudson, Western Reserve College. | 41 15 | 81 26.0 | 1838 | Sept. | 72 48.2 | ---- |
| Do. | 41 15 | 81 26.0 | 1839 | Apr., May, Aug., Oct. | 72 47.3 | ---- |
| Do. | 41 15 | 81 26.0 | 1840 | ----<br>Jan. to Aug. | 72 53.9<br>72 49.5 | 4.039 |
| Do. | 41 15 | 81 26.0 | 1841 | May–Nov. | 72 48.3 | ---- |
| Windham. | 41 15 | 81 03 | 1840 | ---- | 73 03.4 | ---- |
| Shakersville. | 41 15 | 81 13 | 1840 | ---- | 72 56.6 | ---- |
| Streetsboro'. | 41 15 | 81 20 | 1840 | ---- | 72 53.0 | ---- |
| Warren. | 41 16 | 80 49 | 1840 | ---- | 73 00.7 | ---- |
| Do. | 41 17 | 80 50 | 1841 | Aug. | 72 59.9 | 3.978 |
| Do. | 41 16 | 80 54 | 1844 | June 25. | 72 55.9 | 4.005 |
| Hartford. | 41 19 | 80 34 | 1840 | ---- | 72 59.8 | ---- |
| Bazetta. | 41 20 | 80 45 | 1840 | ---- | 72 59.7 | ---- |
| Aurora. | 41 20 | 81 20 | 1840 | ---- | 72 55.5 | ---- |
| Twinsburgh. | 41 20 | 81 26 | 1840 | ---- | 72 51.3 | ---- |
| Bedford. | 41 24 | 81 32 | 1840 | ---- | 72 58.1 | ---- |
| Huron. | 41 26 | 82 27 | 1843 | June 6. | 73 00.0 | 4.019 |
| Sandusky, south of village. | 41 29 | 82 43 | 1839 | May. | 72 57.8 | ---- |
| Kinsman. | 41 30 | 80 34 | 1840 | ---- | 73 08.1 | ---- |
| Brooklyn, 1 mile west of city. | 41 30 | 81 43 | 1841 | Apr. | 73 16.3 | ---- |
| Cleveland, front of American Hotel. | 41 30 | 81 42 | 1839 | May. | 73 26.0 | ---- |
| Cleveland. | 41 30 | 81 42 | 1840 | ---- | 73 14.1 | ---- |
| Do. | 41 30 | 81 42 | 1841 | Aug. | 73 04.3 | ---- |
| Cleveland, front of hill, near landing. | 41 30.3 | 81 42 | 1842 | Nov. 3. | 73 03.8 | ---- |
| Cleveland. | 41 30 | 81 42 | 1843 | Aug. 4. | 73 08 | 4.005 |
| Cleveland, near Marine Hospital. | 41 30.0 | 81 40.0 | 1859 | July 4. | 73 20 | 3.956 |
| Cleveland. | 41 30.5 | 81 41.5 | 1871 | Nov. 6–14. | 73 09.3 | 4.000 |
| Cleveland, near Marine Hospital. | 41 30 | 81 40 | 1872 | June 17, 18. | 73 07 | 4.017 |
| Do. | 41 30 | 81 40 | 1873 | June 16, 17. | 73 08 | 3.996 |
| Cleveland. | 41 30.5 | 81 41.5 | 1880 | July 9, 12. | 73 02.4 | 3.996 |
| Maumee, north of village. | 41 34 | 83 37 | 1839 | May. | 72 49.1 | ---- |
| Toledo, west of village. | 41 41 | 83 32 | 1839 | May. | 73 06.1 | ---- |
| Ashtabula, close to Lake. | 41 52 | 80 52 | 1844 | June 24. | 73 25.0 | 3.911 |
| Ashtabula Landing. | 41 54 | 80 47 | 1841 | Aug. | 72 23.5 | 3.838 |

*intensities in the United States and adjacent regions.—Continued.*

OHIO—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| ---- | 71.80 | ---- | ---- | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843; Prof. E. Loomis. |
| 13.57 | 72.08 | 4.12 | 13.38 | J. Locke. | Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844. |
| ---- | 71.89 | 4.150 | 13.35 | F. E. Hilgard and W. Diehl. | C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser. |
| ---- | 72.13 | ---- | ---- | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843; Prof. E. Loomis. |
| ---- | 72.21 | ---- | ---- | Do. | Do. |
| ---- | 72.37 | ---- | ---- | Do. | Do. |
| ---- | | | | Do. | Sill. J., 1840. |
| ---- | | | | Do. | Do. |
| 13.55 | 72.28 | 4.08 | 13.41 | Do. | Sill. J., 1840, and Trans. Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | | | | Do. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | 72.53 | ---- | ---- | Do. | Phil. Trans. R. S., 1846. |
| ---- | 72.41 | ---- | ---- | Do. | Do. |
| ---- | 72.35 | ---- | ---- | Do. | Do. |
| ---- | | | | Do. | Do. |
| ---- | 72.46 | 4.04 | 13.42 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.65 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | 72.47 | ---- | ---- | E. Loomis. | Phil. Trans. R. S., 1846. |
| ---- | 72.47 | ---- | ---- | Do. | Do. |
| ---- | 72.40 | ---- | ---- | Do. | Do. |
| ---- | 72.33 | ---- | ---- | Do. | Do. |
| ---- | 72.45 | ---- | ---- | Do. | Do. |
| 13.75 | 72.49 | 4.07 | 13.54 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | 72.42 | ---- | ---- | E. Loomis. | Sill. J., 1840. |
| ---- | 72.61 | ---- | ---- | Do. | Phil. Trans. R. S., 1846. |
| ---- | | | | Do. | Am. Phil. Soc., Vol. VIII, 1843. Prof. E. Loomis. |
| ---- | | | | Do. | Sill. J., 1840. |
| ---- | | | | Do. | Phil. Trans. R. S., 1846. |
| ---- | | | | Do. | Am. Phil. Soc., Vol. VIII, 1843. |
| 13.666 | | | | C. Younghusband. | Diary Mag. Sur. Canada. London, 1883, Sir. J. H. Lefroy. |
| 13.80 | 72.74 | 4.046 | 13.64 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844, and Sill. J., Vol. IV, 1847. |
| 13.794 | | | | W. P. Smith. | U. S. Lake Survey Rpt., 1859. |
| 13.80 | | | | E. Goodfellow. | C. & G. S. Rpt., 1881, App. 9. |
| 13.833 | | | | A. N. Lee. | U. S. Lake Survey MS., 1873. |
| 13.773 | | | | Do. | Do. |
| 13.70 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 72.28 | ---- | ---- | E. Loomis. | Sill. J., 1840. |
| ---- | 72.56 | ---- | ---- | Do. | Do. |
| 13.71 | 72.91 | 3.97 | 13.51 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | (71.88) | 3.88 | (12.49) | A. D. Bache. | C. S. Rpt., 1862, App. 19. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

OREGON.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Jacksonville, grounds of public school. | 42 18 | 122 58 | 1881 | July 16, 17. | 66 03.2 | 5.021 |
| Canyonville, Pine street, between Second and Third. | 42 54 | 123 18 | 1881 | July 19. | 65 57.9 | ---- |
| Oakland, academy grounds. | 43 26 | 123 18 | 1881 | July 22. | 66 59.4 | ---- |
| Eugene, grounds of State University. | 44 03 | 123 00 | 1881 | July 25. | 67 51.0 | 4.796 |
| River Santiam. | 44 35 | 122 27 | 1830 | Aug. | 68 28 | 4.647 |
| Albany, College Square. | 44 39 | 123 02 | 1881 | July 27, 28. | 68 08.5 | 4.715 |
| Salem, near State Capitol and court-house. | 44 56.5 | 122 58 | 1881 | July 30, 31. | 68 13.3 | 4.702 |
| River Multnomah. | 45 15 | 122 47 | 1830 | Aug. | 68 57 | 4.514 |
| Portland, west of Clarendon Hotel. | 45 31.5 | 122 40.5 | 1880 | May 1. | 69 35.6 | 4.414 |
| Portland, court-house block. | 45 31.5 | 122 41.5 | 1881 | Aug. 5, 6. | 69 24.2 | 4.488 |
| Dalles, three-mile camp. | 45 35 | 120 49 | 1860 | May 21. | 69 41.8 | ---- |
| Three-Mile Creek, top of north bank. | 45 39 | 120 58 | 1881 | Oct. 13, 14. | ---- | 4.473 |
| Blalock, near Griffin's house and railroad station. | 45 44 | 120 15 | 1881 | Oct. 8. | ---- | 4.495 |
| Saint Helen's. | 45 52.3 | 122 48.1 | 1881 | Aug. 15. | 70 54.1 | 4.350 |
| Umatilla, on First street, near D. | 45 57 | 119 20 | 1881 | Oct. 5. | 70 10.2 | 4.421 |
| Point George, Columbia River. | 46 11 | 123 40 | 1830 | Dec. | 69 16.8 | ---- |
| Astoria, school-house block. | 46 11.5 | 123 50 | 1881 | Aug. 10, 11. | 69 13.4 | 4.508 |

PENNSYLVANIA.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Near Mercersburg. | 39 47 | 77 56 | 1840 | Aug. | 71 47.3 | 4.188 |
| Chambersburg. | 39 55 | 77 40 | 1842 | Apr. 9. | 71 57.1 | 4.197 |
| York, west bank of river. | 39 58 | 76 44 | 1874 | July 13. | 71 54.5 | 4.182 |
| Philadelphia, yard of Bache's house, Chestnut street. | 39 58 | 75 10 | 1834 | July. | 72 00.2 | ---- |
| Do. | 39 58 | 75 10 | 1835 | ---- | ---- | 4.195 |
| Do. | 39 58 | 75 10 | 1836 | Sept. | ---- | 4.159 |
| Philadelphia, Rittenhouse Square. | 39 58 | 75 10 | 1838 | July. | 71 43.9 | ---- |
| Philadelphia, front of Dr. Bache's house. | 39 58 | 75 10 | 1839 | Sept. | 72 07.1 | 4.149 |
| Philadelphia. | 39 58 | 75 10 | 1840 | July, Sept., Oct. | 71 53.0 | ---- |
| Philadelphia, Girard College. | 39 58.4 | 75 10.2 | 1841 | Mar. 30. | 72 00.2 | 4.179 |
| | | | | Mar. 31. | 72 01.3 | 4.175 |
| | | | | Apr. 26. | 71 59.0 | 4.171 |
| Do. | 39 58.4 | 75 10.2 | 1841 | Apr. 26; July 20; Oct. 9; Nov. 1. | 71 58.7 | 4.176 |
| Do. | 39 58.4 | 75 10.2 | 1841 | June. | 71 54.5 | ---- |
| Do. | 39 58.4 | 75 10.2 | 1842 | May 15. | 72 01 | 4.178 |
| Do. | 39 58.4 | 75 10.2 | 1842 | Oct. 6. | 71 59.0 | 4.176 |

*intensities in the United States and adjacent regions.—Continued.*

OREGON.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 12.37 | 66.05° | 5.004 | 12.33 | J. S. Lawson. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 65.96 | ---- | .... | Do. | Do. |
| ---- | 66.98 | ---- | ---- | Do. | Do. |
| 12.72 | 67.84 | 4.779 | 12.67 | Do. | Do. |
| 12.66 | ---- | 4.650 | ---- | D. Douglas. | Rpt. Brit. Asso., Vol. VI, London, 1838, & Phil. Trans. R. S., 1872, Cont. XIII. |
| 12.66 | 68.13 | 4.698 | 12.61 | J. S. Lawson. | C. & G. S Rpt., 1881, App. 9. |
| 12.67 | 68.21 | 4.685 | 12.62 | Do. | Do. |
| 12.57 | ---- | 4.517 | ---- | D. Douglas. | Rpt. Brit. Asso., Vol. VI, London, 1838, & Phil. Trans. R. S., 1872, Cont. XIII. |
| 12.66 | 69.47 | 4.444 | 12.67 | W. H. Dall and M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| 12.76 | | | | J. S. Lawson. | Do. |
| 13.151 | 69.7 | 4.448 | 12.82 | R. W. Haig. | B. S. Phil. Trans. R. S., 1864. |
| ---- | ---- | 4.456 | ---- | J. S. Lawson. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | ---- | 4.478 | ---- | Do. | Do. |
| 13.29 | 70.89 | 4.333 | 13.24 | Do. | Do. |
| 13.03 | 70.15 | 4.405 | 12.97 | Do. | Do. |
| ---- | 69.20 | 4.491 | 12.65 | D. Douglas. | Rpt. Brit. Asso., Vol. VI, London, 1838. |
| 12.71 | | | | J. S. Lawson. | C. & G. S. Rpt., 1881, App. 9. |

PENNSYLVANIA.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| ---- | 71.27 | 4.230 | 13.17 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.55 | 71.44 | 4.247 | 13.34 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | 71.46 | 4.224 | 13.28 | F. E. Hilgard and W. Diehl. | C. & G. S. Rpt., 1882, App. 14. Nat. Acad. Ser. |
| ---- | | | | A. D. Bache and E. H. Courtenay. | Sill. J., Vol. XXXIV, 1838. E. Loomis. |
| 13.58 | | | | Do. | Am. Phil. Soc., Vol. V, 1837, and C. S. Rpt., 1861, App. 22. |
| 13.46 | | | | A. D. Bache. | C. S. Rpt., 1861, App. 22. |
| ---- | | | | Do. | Sill. J., Vol. XXXIX, 1840. E. Loomis. |
| 13.41 | | | | E. Loomis. | Phil. Trans. R. S., 1846, E. Sabine, & C. S. Rpt., 1861, App. 22. |
| ---- | | | | A. D. Bache. | Sill. J., Vol. XLII, 1842, & C. S. Rpt., 1864, App. 18. |
| 13.52 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.55 | | | | | |
| 13.48 | | | | | |
| 13.50 | | | | A. D. Bache. | C. S. Rpt., 1864, App. 18. p.202 (dip only) |
| ---- | | | | J. D. Graham and A. D. Bache. | Phil. Trans. R. S., 1846. Sir E. Sabine. |
| 13.53 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844. |
| 13.577 | | | | J. H. Lefroy. | Diary Mag. Sur. Canada, London, 1883. θ H. & F. obs'd. |
| | 71.38 | 4.230 | 13.25 | | |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

PENNSYLVANIA—Continued.

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Philadelphia, Girard College. | 39 58 | 75 10 | 1842 | ---- | 72 01.8 | ---- |
| Do. | 39 58.4 | 75 10.2 | 1842 | Jan. to Dec. | 72 00.1 | 4.174 |
| Do. | 39 58.4 | 75 10.2 | 1843 | Apr. to Dec. | 71 58.2 | 4.172 |
| Do. | 39 58.4 | 75 10.2 | 1844 | Apr. 19. | 71 59.2 | 4.158 |
| Philadelphia, Rittenhouse Square. | 39 58 | 75 10 | 1844 | May. | 72 09.2 | ---- |
| Philadelphia, Girard College. | 39 58.4 | 75 10.2 | 1844 | Jan. to July. | 71 57.6 | 4.169 |
| Do. | 39 58.4 | 75 10.2 | 1845 | Jan. to June. | ---- | 4.167 |
| Do. | 39 58.4 | 75 10.2 | 1846 | May 23. | 72 01.0 | 4.143 |
| Philadelphia, Girard College, northeast station. | 39 58.4 | 75 10.2 | 1855 | Sept. 5. | 72 17.7 | 4.211 |
| Do. | 39 58.4 | 75 10.2 | 1862 | Aug 15, 16. | 72 05.8 | 4.124 |
| Philadelphia, Navy-Yard. | 39 56 | 75 07 | 1865 | Oct. 24. | ---- | 4.148 |
| Philadelphia, Girard College. | 39 58.4 | 75 10.2 | 1872 | Oct. 19–22. | 72 15.4 | 4.161 |
| Do. | 39 58.3 | 75 10.3 | 1877 | Oct. 2–6. | 71 41.3 | 4.211 |
| Philadelphia, Exhibition Laboratory. | 39 57.1 | 75 11.0 | 1884 | Aug. 29–31. | 71 30.7 | 4.196 |
| Philadelphia, Girard College. | 39 58.3 | 75 10.3 | 1884 | Sept. 3–11. | 71 27.4 | 4.232 |
| Yard, primary triangulation station. | 39 58.3 | 75 23.1 | 1854 | Oct. 28; Nov. 3. | 73 01.2 | 3.876 |
| Near Brownsville. | 39 59.5 | 79 47.8 | 1840 | Aug. | 71 53.5 | 4.207 |
| Johnson's tavern, near Brownsville. | 39 59.5 | 79 48.1 | 1862 | July 31. | 71 57.0 | 4.173 |
| Bristol. | 40 05.6 | 74 51.5 | 1842 | May 13. | 72 25 | 4.046 |
| Bristol, Vanuxem. | 40 06.7 | 74 53.0 | 1846 | June 10, 11, 12. | 72 22.3 | 4.068 |
| Greenfield, near Johnston's tavern. | 40 06 | 79 52 | 1874 | Aug. 13, 14. | 71 58.9 | 4.185 |
| Cumberland. | 40 13 | 76 50 | 1844 | ---- | 71 36.0 | ---- |
| Harrisburg. | 40 16 | 76 53 | 1840 | July. | 72 20.5 | 4.078 |
| Harrisburg, grounds of State House. | 40 15.8 | 76 52.9 | 1862 | July 28, 29. | 72 31.6 | 4.048 |
| Do. | 40 15.8 | 76 52.9 | 1877 | Sept. 27. | 72 20.5 | 4.123 |
| Doylestown. | 40 18 | 75 10 | 1841 | July. | 72 23.1 | 4.189 |
| Reading. | 40 19 | 75 55 | 1840 | July. | 72 32.2 | 4.000 |
| Duncan Island. | 40 25 | 77 01 | 1840 | July. | 72 35.0 | 3.963 |
| Alleghany Summit. | 40 27 | 78 10 | 1845 | May 5. | 72 27.1 | 4.105 |
| Pittsburg. | 40 27 | 80 00 | 1819 | May 1. | 78 12(?) | ---- |
| Pittsburg, opposite side of Allegheny River. | 40 28 | 80 00 | 1839 | Sept. | 72 38.9 | ---- |
| Pittsburg, vicinity of. | 40 28 | 79 59.5 | 1840 | Aug. | 72 32.1 | 4.049 |
| Pittsburg. | 40 28 | 80 00 | 1841 | Mar. 22. | 72 43.5 | 4.059 |
| Do. | 40 28 | 80 00 | 1842 | Apr. 7. | 72 43.2 | 4.056 |
| Do. | 40 27 | 80 00 | 1845 | May 3. | 72 46.7 | 4.034 |
| Allegheny, grounds of Observatory. | 40 27.6 | 80 00.8 | 1878 | Sept. 5. | 72 07.5 | 4.1294 |
| Armagh. | 40 29 | 79 04 | 1840 | Aug. | 72 18.7 | 4.038 |
| Huntingdon. | 40 30.5 | 78 02 | 1840 | July. | 72 17.8 | 4.109 |

***intensities in the United States and adjacent regions.—Continued.***

PENNSYLVANIA—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| ---- | | | | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| 13.51 | | | | A. D. Bache. | C. S. Rpt., 1864, App. 18. |
| 13.48 | | | | Do. | Do. |
| 13.45 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | | | | J. D. Graham. | Phil. Trans. R. S., 1846. |
| 13.46 | | | | A. D. Bache. | C. S. Rpt., 1864, App. 18. |
| ---- | | | | Do. | Do. |
| 13.42 | | | | J. Locke. | C. & G. S. Rpt., 1881, App. 9. |
| 13.85 | | | | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9 (recomputed). |
| 13.42 | | | | Do. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | W. Harkness. | Smithsonian Cont's to Know., No. 239, Wash., 1873, Cruise of the Monadnock. |
| 13.65 | | | | A. H. Scott and E. Goodfellow. | C. & G. S. Rpt., 1881, App. 9. |
| 13.40 | | | | J. B. Baylor. | Do. |
| 13.233 | | | | E. Smith. | MS. in C. & G. S. Office. |
| 13.307 | | | | Do. | Do. |
| 13.27 | 72.44 | 3.961 | 13.13 | J. E. Hilgard. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 71.36 | 4.251 | 13.30 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.47 | | | | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.40 | 71.88 | 4.115 | 13.23 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.43 | | | | Do. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 71.53 | 4.227 | 13.34 | F. E. Hilgard and W. Diehl. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| 13.54 | 71.10 | 4.332 | 13.37 | J. Locke. | Phil. Trans. R. S., 1846. |
| ---- | | | | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.48 | 71.92 | 4.133 | 13.32 | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.59 | | | | E. Smith and J. B. Baylor. | Do. |
| ---- | 71.86 | 4.235 | 13.60 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| ---- | 72.01 | 4.042 | 13.09 | Do. | Do. |
| ---- | 72.05 | 4.005 | 13.00 | Do. | Do. |
| 13.62 | 71.94 | 4.167 | 13.44 | J. Locke. | Phil. Trans. R. S. 1846. Smithsonian Cont's to Know., Vol. III, 1852. |
| ---- | | | | S. H. Long. | Maj. Long's Exp. to Rocky Mts., 2 vols., Phila., 1823. Dip probably 73° 12′. (Loomis.) |
| ---- | | | | E. Loomis. | Sill. J., 1840. |
| ---- | | | | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.67 | 72.11 | 4.110 | 13.38 | J. Locke. | Sill. J., Vol. IV, 1847, and Trans. Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844. |
| 13.66 | | | | Do. | Am. Phil. Soc., 1846, Art. XI; Dr. J. Locke's paper of 1844. |
| ---- | | | | Do. | Smithsonian Cont's to Know., Vol. III, 1852. |
| 13.453 | | | | T. E. Thorpe. | Proc. R. S., No. 200, 1880. |
| ---- | 71.80 | 4.080 | 13.06 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| ---- | 71.77 | 4.151 | 13.27 | Do. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

PENNSYLVANIA—Continued.

| Name of station. | Latitude φ. | West longitude λ | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Altoona. | 40 30.6 | 78 25 | 1874 | July 16. | 72 21.7 | 4.120 |
| Lewistown. | 40 35.5 | 77 35.5 | 1840 | July. | 72 30.0 | 3.984 |
| Economy. | 40 37 | 80 16 | 1840 | Aug. | 72 35.0 | 4.008 |
| Bethlehem, Lehigh College Observatory. | 40 37.5 | 75 18.0 | 1874 | June 20. | 73 38.9 | 3.839 |
| Easton. | 40 42 | 75 15 | 1841 | July. | 72 39.0 | 4.121 |
| Beaver, bank building, near Beaver Bridge. | 40 43.7 | 80 18 | 1839 | Oct. | 72 40.3 | ---- |
| Beaver, near the river. | 40 43.5 | 80 16 | 1874 | Aug. 11. | 72 31.5 | 4.056 |
| Bellefonte. | 40 55 | 77 49 | 1841 | July. | 72 42.3 | 4.069 |
| Curwinsville. | 40 57.5 | 78 36 | 1841 | Aug. | 72 49.7 | 3.999 |
| Bushkill. | 41 07 | 75 00 | 1841 | Aug. | 73 31.4 | 3.866 |
| Mercer. | 41 13.8 | 80 16 | 1841 | Aug. | 72 57.2 | 4.000 |
| Wilkesbarre. | 41 14 | 75 58 | 1841 | July. | 73 10.0 | 3.961 |
| Williamsport. | 41 14 | 77 02 | 1841 | July. | 72 54.4 | 3.983 |
| Williamsport, near old Academy building. | 41 14.0 | 77 02.4 | 1862 | Aug. 13. | 72 51.0 | 3.958 |
| Williamsport, field west of Woodward's house. | 41 15 | 77 03 | 1874 | July 18, 20. | 72 47.5 | 4.003 |
| Berlin Tavern. | 41 16 | 79 36 | 1841 | Aug. | 72 52.8 | 4.026 |
| Sharpsville. | 41 17 | 80 27 | 1874 | Aug. 6. | 72 50.7 | 4.002 |
| Milford. | 41 19 | 74 51.5 | 1841 | Aug. | 73 47.6 | 3.769 |
| Silver Lake. | 41 56.6 | 76 02 | 1841 | Aug. 23. | ---- | 3.782 |
| Erie, near French and Seventh streets. | 42 07.5 | 80 06.3 | 1841 | Aug. | 73 46.6 | 3.792 |
| Erie, Presque Isle Harbor. | 42 09.8 | 80 05.3 | 1859 | June 7. | 73 56 | 3.784 |
| Erie, same place as in 1841, near school-house. | 42 07.5 | 80 06.3 | 1862 | Aug. 6, 7. | 73 52.3 | 3.761 |
| Erie, on Peninsula, near beacon light. | 42 08.2 | 80 05.3 | 1873 | June 11, 12. | 73 46 | 3.829 |
| **RHODE ISLAND.** | | | | | | |
| Point Judith. | 41 21.6 | 71 28.9 | 1847 | Sept. 6–14. | 73 45.1 | 3.788 |
| Newport. | 41 29 | 71 19 | 1835 | ---- | ---- | 3.775 |
| Coaster's (Harbor) Island, near Newport. | 41 30.5 | 71 19.7 | 1885 | Apr. 21, 22, 23. | 73 03.4 | 3.856 |
| McSparran, summit of hill. | 41 29.7 | 71 27.4 | 1844 | July 13–24. | 73 47.6 | ---- |
| Spencer. | 41 40.7 | 71 29.7 | 1844 | July, Aug., Sept. | 75 07.1 | ---- |
| Providence, north of Brown University. | 41 50.3 | 71 24 | 1834 | Aug. | 74 02.8 | ---- |
| Do. | 41 50.3 | 71 23.9 | 1835 | ---- | ---- | 3.770 |
| Providence, steamboat landing. | 41 49 | 71 25 | 1839 | Sept. | 73 59.6 | 3.726 |
| Providence. | 41 50 | 71 25 | 1841 | ---- | 74 02.8 | ---- |
| Providence, near steamboat landing. | 41 49 | 71 25 | 1842 | Sept. 28. | 74 00.0 | 3.715 |
| Providence, east of Brown University. | 41 50.2 | 71 23.7 | 1855 | Aug. 20. | 74 15.9 | 3.590 |
| Do. | 41 50.2 | 71 23.7 | 1885 | Apr. 11, 13, 14. | 73 10.5 | 3.814 |
| Providence. | 41 50 | 71 24 | 1884 | June 20. | 73 16.6 | 3.7685 |
| Beaconpole. | 41 59.7 | 71 27.0 | 1844 | Nov. 8–19. | 74 21.9 | ---- |

*intensities in the United States and adjacent regions.—Continued.*

PENNSYLVANIA—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| ---- | 71.91° | 4.162 | 13.40 | F. E. Hilgard and W. Diehl. | C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser. |
| ---- | 71.98 | 4.026 | 13.01 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| ---- | 72.06 | 4.050 | 13.15 | Do. | Do. |
| 13.64 | 73.20 | 3.881 | 13.43 | T. C. Hilgard. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 72.13 | 4.167 | 13.58 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| ---- | 72.11 | 4.098 | 13.34 | E. Loomis. | Sill. J., 1840. |
| ---- | | | | F. E. Hilgard and W. Diehl. | C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser. |
| ---- | 72.18 | 4.115 | 13.45 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| ---- | 72.31 | 4.045 | 13.31 | Do. | Do. |
| ---- | 73.00 | 3.912 | 13.38 | Do. | Do. |
| ---- | 72.43 | 4.046 | 13.40 | Do. | Do. |
| ---- | 72.65 | 4.007 | 13.44 | Do. | Do. |
| ---- | | | | Do. | Do. |
| 13.42 | 72.30 | 4.037 | 13.28 | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | F. E. Hilgard and W. Diehl. | C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser. |
| ---- | 72.36 | 4.072 | 13.44 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| ---- | 72.39 | 4.044 | 13.37 | F. E. Hilgard and W. Diehl. | C. & G. S. Rpt., 1882, App. 14; Nat. Acad. Ser. |
| ---- | 73.27 | 3.815 | 13.25 | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| ---- | ---- | 3.828 | ---- | Do. | Do. |
| ---- | | | | Do. | Do. |
| 13.661 | 73.29 | 3.856 | 13.41 | W. P. Smith. | U. S. Lake Sur., Capt. G. G. Meade, 1859. |
| 13.54 | | | | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.697 | | | | A N. Lee. | U. S. Lake Sur., Gen. C. B. Comstock, 1873. |

RHODE ISLAND.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 13.54 | 72.85 | 3.871 | 13.13 | R. H. Fauntleroy. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | ---- | 3.785 | ---- | A. D. Bache and E. H. Courtenay. | Am. Phil. Soc , Phila., Vol. V, 1837; C. S. Rpt., 1861, App. 22. H at Phila. = 4.195 used as unit. (Schott.) |
| 13.23 | 73.09 | 3.854 | 13.25 | J. B. Baylor. | MS. in U. S. C. & G. S. Office. |
| ---- | 72.92 | ---- | ---- | A. D. Bache and T. J. Lee. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 74.25 | ---- | ---- | T. J. Lee. | Do. |
| ---- | | | | A. D. Bache. | Sill. J., 1838, E. Loomis. |
| 13.72 | | | | A. D. Bache and E. H. Courtenay. | Am. Phil. Soc., Phila., Vol. V, 1837; C. S. Rpt., 1861, App. 22. H at Phila. = 4.195 used as unit. (Schott.) |
| 13.41 | | | | E. Loomis. | Sill. J., 1840, & C. S. Rpt., 1861, App. 22. |
| ---- | 73.19 | 3.768 | 13.03 | A. D. Bache. | Phil. Trans. R. S., 1846. |
| 13.477 | | | | J. H. Lefroy. | Diary Mag. Sur. Canada, London, 1883. |
| 13.24 | | | | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.21 | | | | J. B. Baylor. | MS. in U. S. C. & G. S. Office. |
| 13.151 | | | | O. T. Sherman. | Rpt. Board of Managers Yale College Obser'y, 1884-'85. |
| ---- | 73.49 | ---- | ---- | T. J. Lee. | C. & G. S. Rpt., 1881, App. 9. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

SOUTH CAROLINA.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Graham, near bank of Scull Creek. | 32 13.3 | 80 45.5 | 1870 | Mar., Apr. | 63 28.1 | 5.663 |
| Port Royal, Saint Helena Island. | 32 17.7 | 80 38.5 | 1859 | Jan. 28, 29, 30. | 64 07.5 | ---- |
| Beaufort, corner Wilmington and Bay streets. | 32 26.0 | 80 40.5 | 1874 | Apr. 16–25. | ---- | 5.603 |
| Do. | 32 26.0 | 80 40.5 | 1875 | Apr. 9, 10, 12. | ---- | 5.586 |
| East Base, Edisto Island. | 32 33.3 | 80 13.5 | 1850 | Apr. 5–11. | 64 04.1 | 5.623 |
| Charleston. | 32 47 | 79 56 | 1833 | Jan. | ---- | 5.920 |
| Breach Inlet, near Charleston. | 32 46.3 | 79 48.9 | 1849 | Apr. 6–25. | 64 31.9 | 5.547 |
| Fort Marshall, near Breach Inlet. | 32 46.4 | 79 48.8 | 1874 | May 27, 28. | ---- | 5.530 |
| Breach Inlet, near Truesdale's house. | 32 46.4 | 79 48.8 | 1880 | Jan. 21, 22. | 64 13.7 | 5.530 |
| Allston, near Georgetown. | 33 21.6 | 79 16.6 | 1853 | Dec. 24–27. | 65 29.5 | 5.439 |
| Columbia, Capitol Square. | 34 00.0 | 81 02.1 | 1854 | Feb. 24–Mar. 1. | 66 07.7 | 5.296 |

TENNESSEE.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Chattanooga, near Staunton House. | 35 00 | 85 18 | 1881 | July 28, 29. | 66 09.7 | 5.307 |
| Grand Junction, northwest of railroad depot. | 35 05 | 89 13 | 1881 | Sept. 9, 10. | 66 00.4 | 5.268 |
| Memphis. | 35 09 | 90 03 | 1872 | May 21. | 65 37.5 | 5.296 |
| Pulaski, grounds of Martin College. | 35 13 | 87 03 | 1881 | Aug. 23, 24, 25. | 66 06.4 | 5.251 |
| Tullahoma, rear of Episcopal church. | 35 22 | 86 13 | 1881 | Aug. 3, 5. | 66 25.5 | 5.215 |
| Athens, East Tennessee and Wesleyan University. | 35 27 | 84 37 | 1881 | July 20, 21. | 66 11.7 | 5.290 |
| Columbia, grounds of Episcopal Institute. | 35 37 | 87 04 | 1881 | Aug. 17, 18. | 67 07.5 | 5.140 |
| Jackson, court-house grounds. | 35 39 | 88 51 | 1881 | Sept. 16, 17. | 66 05.4 | 5.272 |
| Murfreesboro', grounds of Union University. | 35 53 | 86 25 | 1881 | Aug. 10, 11. | 66 53.3 | 5.175 |
| Knoxville. | 35 58 | 83 55 | 1833 | Sept. | 67 06 | --- |
| Knoxville, grounds Deaf and Dumb Asylum. | 35 57.3 | 83 56 | 1873 | Aug. 11. | 66 55.3 | 5.093 |
| Rutherford, on Main street, near Corley Hotel. | 36 09 | 89 01 | 1881 | Sept. 20, 21. | 67 13.8 | 5.118 |
| Nashville. | 36 10 | 86 48 | 1833 | Nov. | 67 05 | 4.568 |
| Do. | 36 09.7 | 86 47.6 | 1877 | Dec. 5, 6, 7. | 67 18.9 | 5.110 |
| Edgefield, in front of Settle's estate. | 36 15 | 86 46 | 1871 | Dec. 1. | 67 10.7 | 4.478(?) |
| Caryville, near Wheeler's house. | 36 19 | 84 14 | 1881 | July 14, 15. | 67 55.7 | 4.972 |
| Rogersville. | 36 25 | 83 03 | 1873 | Aug. 18. | 68 26.2 | 4.982 |
| Bristol. | 36 35.9 | 82 11 | 1873 | Aug. 20. | 68 11.0 | 4.900 |
| Bristol, Jameson's lot. | 36 35.8 | 82 11 | 1881 | July 9–13. | 68 01.0 | 4.891 |

TEXAS.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Mouth of Rio Grande. | 25 57.4 | 97 07.9 | 1853 | Nov. | 52 23.6 | ---- |
| Ringgold Barracks. | 26 23 | 98 43 | 1853 | ---- | 52 27 | ---- |

***intensities in the United States and adjacent regions.**—Continued.*

SOUTH CAROLINA.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| 12.68 | ° 63.11 | 5.678 | 12.55 | C. O. Boutelle. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 63.72 | ---- | ---- | Do. | Do. |
| ---- | } ---- | 5.605 | ---- { | Do. | Do. |
| ---- | | | | Do. | Do. |
| 12.86 | 63.71 | 5.64 | 12.73 | G. Davidson. | Do. |
| ---- | ---- | ---- | ---- | J. N. Nicollet. | C. S. Rpt., 1864, App. 19. |
| 12.90 | | | | C. O. Boutelle, J. Hewston, and G. W. Dean. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | } 64.11 | 5.535 | 12.68 { | C. O. Boutelle and J. B. Boutelle. | Do. |
| 12.72 | | | | J. B. Baylor. | Do. |
| 13.11 | 65.10 | 5.46 | 12.97 | C. O. Boutelle. | Do. |
| 13.09 | 65.74 | 5.32 | 12.95 | G. W. Dean. | Do. |

TENNESSEE.

| | | | | | |
|---|---|---|---|---|---|
| 13.13 | 66.04 | 5.30 | 13.05 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 12.96 | 65.88 | 5.27 | 12.90 | Do. | Do. |
| ---- | 65.30 | 5.29 | 12.66 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14 (Nat. Acad. Ser.). |
| 12.96 | 65.99 | 5.25 | 12.90 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.04 | 66.30 | 5.21 | 12.96 | Do. | Do. |
| 13.11 | 66.08 | 5.29 | 13.05 | Do. | Do. |
| 13.22 | 67.00 | 5.14 | 13.16 | Do. | Do. |
| 13.01 | 65.97 | 5.27 | 12.94 | Do. | Do. |
| 13.18 | 66.77 | 5.17 | 13.11 | Do. | Do. |
| ---- | } 66.65 | 5.09 | 12.84 { | J. N. Nicollet. | C. S. Rpt., 1864, App. 19. |
| ---- | | | | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14 (Nat. Acad. Ser.). |
| 13.22 | 67.11 | 5.12 | 13.17 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | } 67.37 | 5.11 | 13.28 { | J. N. Nicollet. | C. S. Rpt., 1864, App. 19. |
| 13.25 | | | | A. Braid. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 66.85 | ---- | ---- | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14 (Nat. Acad. Ser.). |
| 13.23 | 67.80 | 4.97 | 13.16 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 68.13 | 4.98 | 13.36 | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14 (Nat. Acad. Ser.). |
| ---- | } 67.89 | 4.89 | 12.99 { | Do. | Do. |
| 13.07 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |

TEXAS.

| | | | | | |
|---|---|---|---|---|---|
| ---- | 53.0 | ---- | ---- | W. H. Emory. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 53.1 | ---- | ---- | Do. | U. S. & Mex. Bound. Sur.; Am. Acad. of Sc., Vol. VI, 1856. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

TEXAS—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Fort McIntosh. | 27 35 | 99 45 | 1852 | ---- | 54 07 | ---- |
| Lavaca. | 28 37.6 | 96 37.3 | 1868 | Apr. 21–24. | 57 11.2 | 6.574 |
| Fort Duncan. | 28 42 | 100 30 | 1852 | ---- | 55 31 | ---- |
| Jupiter. | 28 54.8 | 95 20.6 | 1853 | May 10–17. | 57 11.4 | 6.596 |
| East Base, Galveston Island. | 29 12.9 | 94 55.8 | 1853 | Mar. 17–25. | 57 42.1 | 6.524 |
| San Antonio. | 29 25.4 | 98 29.3 | 1878 | June 10–13. | 57 34.6 | 6.429 |
| Dollar Point. | 29 26.0 | 94 53.4 | 1848 | Apr. 25–May 8. | 57 53.3 | 6.541 |
| Do. | 29 26.0 | 94 53.4 | 1868 | Feb. 24–26. | 58 04.1 | 6.443 |
| Do. | 29 25.9 | 94 53.4 | 1878 | May 30–June 4. | 58 21.5 | 6.373 |
| Everett's house, mouth of Sabine. | 29 43.9 | 93 51.5 | 1840 | Feb. | 58 32.9 | ---- |
| Austin. | 30 16.4 | 97 44.2 | 1878 | June 21–25. | 58 56.7 | 6.269 |
| Mouth of cañon. | 31 02 | 105 37 | 1852 | ---- | 57 38 | ---- |
| San Elceario. | 31 35 | 106 16 | 1852 | ---- | 58 57 | ---- |
| Frontera. | 31 49 | 106 33 | 1852 | ---- | 59 05 | ---- |
| Longview, north of depot. | 32 29 | 94 34 | 1872 | Apr. 15. | 61 57.6 | 5.790 |
| Fort Worth. | 32 45.3 | 97 19.9 | 1878 | July 4–9. | 61 53.1 | 5.921 |

UTAH TERRITORY.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Deseret, railroad station. | 39 17.6 | 112 37.7 | 1884 | Sept. 24, 25, 26. | 65 34.8 | 5.217 |
| Scipio. | 39 23.5 | 112 12.4 | 1884 | Sept. 1, 2, 3. | 65 38.8 | 5.178 |
| Sulphur. | 39 41 | 113 46 | 1859 | ---- | 65 07 | ---- |
| Nephi. | 39 42.4 | 111 51.0 | 1883 | Nov. 7, 8, 9. | 66 26.2 | 5.104 |
| Do. | 39 42.4 | 111 51.0 | 1884 | July 31; Aug. 1, 2 | 66 04.6 | ---- |
| Simpson's Spring. | 40 02 | 112 47 | 1859 | ---- | 66 54 | ---- |
| Camp Floyd. | 40 13 | 112 08 | 1859 | ---- | 66 29 | ---- |
| Provo City. | 40 14.8 | 111 40.0 | 1883 | Nov. 11, 12, 13. | 66 41.0 | 5.074 |
| Do. | 40 14.8 | 111 40.0 | 1884 | Oct. 1, 2. | 66 36.4 | ---- |
| Salt Lake City, Temple Square. | 40 46.0 | 111 53.8 | 1869 | May 6–19. | 66 58.2 | 5.044 |
| Salt Lake City, east of president's house. | 40 46.1 | 111 53.7 | 1878 | Aug. 14, 15. | 67 02.3 | 5.0061 |
| Salt Lake City, Fourth Temple street, south, near Second, east. | 40 46.0 | 111 53.8 | 1878 | Oct. 25–31. | 67 05.9 | 4.987 |
| Salt Lake City, Temple Block. | 40 46.0 | 111 53.8 | 1881 | May 12, 13, 14. | 67 02.1 | 5.006 |
| Do. | 40 46.1 | 111 53.8 | 1883 | Nov. 15, 16, 17. | 67 01.2 | 4.9728 |
| Do. | 40 46.0 | 111 53.8 | 1884 | Oct. 22, 23, 24. | 67 05.2 | 4.9770 |
| Ogden, observatory. | 41 13.1 | 111 59.9 | 1878 | Aug. 24. | 67 24.5 | 4.9440 |
| Corinne, western part of town. | 41 33.2 | 112 06.0 | 1881 | May 5, 6, 7. | 67 47.8 | 4.863 |
| Kelton, western part of town. | 41 45.4 | 113 07.5 | 1881 | May 3, 4. | 67 49.7 | 4.865 |

*intensities in the United States and adjacent regions.—Continued.*

TEXAS—Continued.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| ---- | ° 54.8 | ---- | ---- | W. H. Emory. | U. S. & Mex. Bound. Sur.; Am. Acad. of Sc., Vol. VI, 1856. |
| 12.13 | 57.5 | 6.50 | 12.10 | E. Goodfellow. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 56.2 | ---- | ---- | W. H. Emory. | U. S. & Mex. Bound. Sur.; Am. Acad. of Sc., Vol. VI, 1856. |
| 12.18 | 57.8 | ---- | ---- | G. W. Dean. | C. & G. S. Rpt., 1881, App. 9. |
| 12.21 | 58.3 | 6.45 | 12.28 | Do. | Do. |
| 11.99 | 58.0 | 6.40 | 12.08 | J. B. Baylor. | Do. |
| 12.30 | | | | R. H. Fauntleroy. | Do. |
| 12.18 | 58.47 | 6.35 | 12.14 | E. Goodfellow. | Do. |
| 12.15 | | | | J. B. Baylor. | Do. |
| ---- | 58.6 | ---- | ---- | J. D. Graham. | Sill. J., Vol. IV, 1847. Also Am. Alm., 1881. |
| 12.15 | 59.0 | 6.24 | 12.12 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 11.28 | ---- | 5.90 | ---- | W. H. Emory. | U. S. & Mex. Bound. Sur.; Am. Acad. of Sc., Vol. VI, 1856. |
| ---- | 58.9 | ---- | ---- | Do. | Do. |
| ---- | 59.0 | ---- | ---- | Do. | Do. |
| ---- | 61.9 | 5.74 | 12.19 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| 12.56 | 61.8 | 5.90 | 12.49 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |

UTAH TERRITORY.

| | | | | | |
|---|---|---|---|---|---|
| 12.62 | 65.55 | 5.217 | 12.60 | W. Eimbeck and G. F. Bird | MS. in C. & G. S. Office. |
| 12.56 | 65.62 | 5.178 | 12.54 | Do. | Do. |
| ---- | ---- | ---- | ---- | J. H. Simpson. | Mag. Var. by J. B. Stone, New York, 1878. |
| 12.77 | 66.20 | 5.100 | 12.64 | W. Eimbeck and G. F. Bird | MS. in C. & G. S. Office. |
| ---- | | | | Do. | Do. |
| ---- | ---- | ---- | ---- | J. H. Simpson. | Mag. Var. by J. B. Stone, New York, 1878. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| 12.82 | 66.60 | 5.070 | 12.77 | W. Eimbeck and G. F. Bird | MS. in C. & G. S. Office. |
| ---- | | | | Do. | Do. |
| 12.89 | | | | G. W. Dean and F. H. Agnew. | C. & G. S. Rpt., 1881, App. 9. |
| 12.832 | | | | T. E. Thorpe. | Proc. R. S., No. 200, 1880. |
| 12.81 | 67.05 | 4.972 | 12.75 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 12.83 | | | | W. Eimbeck and R. A. Marr. | Do. |
| 12.737 | | | | W. Eimbeck and G. F. Bird | MS. in C. & G. S. Office. |
| 12.783 | | | | Do. | Do. |
| 12.870 | 67.40 | 4.921 | 12.81 | T. E. Thorpe. | Proc. R. S., No. 200, 1880. |
| 12.87 | 67.79 | 4.851 | 12.83 | W. Eimbeck and R. A. Marr. | C. & G. S. Rpt., 1881, App. 9. |
| 12.89 | 67.82 | 4.853 | 12.86 | Do. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

VERMONT.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Bellows Falls. | 43 09 | 72 28 | 1876 | July 31; Aug. 1. | 74 29.7 | 3.633 |
| Rutland, near bank and near post-office. | 43 36 | 72 55 | 1859 | July 21. | 75 19.8 | 3.464 |
| Rutland. | 43 36.5 | 72 55.5 | 1873 | Oct. 16–18. | 75 05.1 | 3.492 |
| Do. | 43 36.5 | 72 55.5 | 1879 | Oct. 14–15. | 74 49.5 | 3.550 |
| White River Junction. | 43 41 | 72 16 | 1876 | Aug. 3–5. | 75 07.8 | 3.489 |
| Wells River. | 44 09 | 72 05 | 1876 | Aug. 8. | 75 31.0 | 3.438 |
| Montpelier. | 44 17 | 72 36 | 1845 | June 25. | 75 16.2 | 3.429 |
| Burlington. | 44 28 | 73 12 | 1845 | June 26. | 75 37.0 | 3.393 |
| Burlington, flag-staff on camp ground. | 44 29.3 | 73 13.4 | 1855 | Aug. 28. | 75 56.8 | 3.425 |
| Burlington, near college. | 44 28.5 | 73 12.0 | 1873 | Oct. 13–15. | 75 24.2 | 3.427 |
| Canaan Corner. | 45 00 | 71 31 | 1845 | ---- | 76 23.5 | ---- |
| Lake Memphremagog. | 45 00 | 72 13 | 1845 | ---- | 76 08.4 | ---- |
| Derby, near Lake Memphremagog. | 45 00 | 72 12 | 1876 | Aug. 12. | 75 51.0 | 3.318 |

VIRGINIA.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Knott Island, north end. | 36 33.9 | 75 55.3 | 1873 | Apr. 21, 22, 23. | 68 52.5 | 4.760 |
| Danville, Clayburn's Hill. | 36 36.6 | 79 20 | 1873 | July 26. | 68 54.8 | 4.727 |
| Marion, grounds of Marion College. | 36 48 | 81 31 | 1881 | June 30; July 2. | 68 25.7 | 4.846 |
| Norfolk, north and west of City Hall, on Smith's Creek. | 36 51.4 | 76 17.5 | 1856 | Sept. 9. | 69 29.7 | 4.656 |
| Norfolk, south and east of City Hall, open lot, Main and Water streets. | 36 50.5 | 76 17.1 | 1856 | Sept. 10. | 69 28.2 | 4.667 |
| Gosport, navy-yard, opposite Norfolk. | 36 49 | 76 17 | 1865 | Oct. 29. | 69 38 | 4.713 |
| Mount Airy. | 36 51.5 | 79 06 | 1873 | Aug. 21. | 68 54.7 | 4.793 |
| Wytheville, southeast of Boyd's Hotel. | 36 55 | 81 05 | 1881 | June 24, 25. | 68 43.6 | 4.780 |
| Cape Henry light-house. | 36 55.6 | 76 00.4 | 1856 | Sept. 11. | 69 39.0 | 4.623 |
| Do. | 36 55.6 | 76 00.4 | 1874 | Nov. 26, 27, 28. | 69 19.0 | 4.629 |
| Old Point Comfort light-house. | 37 00.0 | 76 18.4 | 1856 | Sept. 8. | 69 31.6 | 4.659 |
| Cape Charles. | 37 07.3 | 75 58.2 | 1856 | Sept. 7. | 69 43.3 | 4.622 |
| Christiansburg, rear of Baptist church. | 37 11.3 | 80 18 | 1873 | Aug. 23. | 69 01.1 | 4.717 |
| Burkeville. | 37 13.2 | 78 12 | 1873 | July 23. | 69 20.4 | 4.609 |
| Petersburg, near geodetic station, Roslyn. | 37 14.4 | 77 23.9 | 1852 | Aug. 6–13. | 69 17.3 | 4.640 |
| Williamsburg, grounds of William and Mary College. | 37 16.3 | 76 42.7 | 1874 | Dec. 4, 10. | 69 27.6 | 4.631 |
| Scott, close to the bay. | 37 20.5 | 75 54.1 | 1856 | Sept. 6. | 70 01.5 | 4.571 |
| Wolftrap. | 37 24.0 | 76 14.7 | 1871 | May 13–20. | 69 46.8 | 4.610 |
| Lynchburg, top of bluff opposite freight station. | 37 24.7 | 79 08.7 | 1873 | July 20. | 69 45.3 | 4.646 |

***intensities in the United States and adjacent regions.—Continued.***

VERMONT.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| ---- | ° 73. 87 | 3. 665 | 13. 20 | F. E. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected—Sch.] |
| 13. 68 | | | | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13. 57 | 74. 34 | 3. 564 | 13. 20 | T. C. Hilgard. | Do. |
| 13. 56 | | | | J. B. Baylor. | Do. |
| ---- | 74. 49 | 3. 521 | 13. 17 | F. E. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected—Sch.] |
| ---- | 74. 88 | 3. 470 | 13. 30 | Do. | Do. |
| ---- | 74. 40 | 3. 495 | 13. 00 | J. Locke. | Smithsonian Cont's to Know., Vol. III, 1852. |
| ---- | | | | Do. | Do. |
| 14. 10 | 74. 78 | 3. 497 | 13. 32 | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13. 60 | | | | T. C. Hilgard. | Do. |
| ---- | 75. 52 | ---- | ---- | J. D. Graham. | Sill. J., Vol. IV, 1847. |
| ---- | 75. 27 | ---- | ---- | Do. | Do. |
| ---- | 75. 21 | 3. 350 | 13. 12 | F. E. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected—Sch.] |

VIRGINIA.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 13. 21 | 68. 40 | 4. 806 | 13. 06 | A. T. Mosman. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 68. 44 | 4. 773 | 12. 99 | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| 13. 18 | 68. 24 | 4. 859 | 13. 11 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13. 29 | | | | C. A. Schott. | Do. |
| 13. 31 | 68. 94 | 4. 760 | 13. 25 | Do. | Do. |
| 13. 542 | | | | W. Harkness. | Smithsonian Cont. to Know., No. 239, Wash., 1873. Cruise of the Monadnock. |
| ---- | 68. 44 | 4. 839 | 13. 17 | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| 13. 17 | 68. 50 | 4. 793 | 13. 08 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13. 29 | 68. 96 | 4. 690 | 13. 06 | C. A. Schott. | Do. |
| 13. 11 | | | | T. C. Hilgard. | Do. |
| 13. 32 | 68. 93 | 4. 744 | 13. 19 | C. A. Schott. | Do. |
| 13. 34 | 69. 12 | 4. 707 | 13. 20 | Do. | Do. |
| ---- | 68. 55 | 4. 763 | 13. 02 | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| ---- | 68. 87 | 4. 655 | 12. 91 | Do. | Do. |
| 13. 12 | 68. 73 | 4. 721 | 13. 01 | G. W. Dean and A. D. Bache. | C. & G. S. Rpt., 1881, App. 9. |
| 13. 20 | 69. 02 | 4. 671 | 13. 05 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13. 38 | 69. 42 | 4. 656 | 13. 25 | C. A. Schott. | Do. |
| 13. 34 | 69. 27 | 4. 665 | 13. 18 | A. T. Mosman. | Do. |
| ---- | 69. 29 | 4. 692 | 13. 27 | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

VIRGINIA—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Richmond, Mayo's Island. | 37 31.7 | 77 26.0 | 1856 | Sept. 19. | 69 47.7 | 4.609 |
| Natural Bridge, in grove front of hotel. | 37 35 | 79 22 | 1873 | Aug. 26. | 69 42.9 | 4.602 |
| Joynes, edge of salt water marsh. | 37 41.7 | 75 36.9 | 1856 | Sept. 4. | 70 21.2 | 4.488 |
| Tangier. | 37 47.9 | 75 59.3 | 1871 | June 16–21. | 70 11.6 | 4.542 |
| Covington, garden of McCurdy House. | 37 48 | 79 59.5 | 1873 | Aug. 28. | 69 47.3 | 4.584 |
| Covington, rear of McCurdy House. | 37 48 | 79 59.5 | 1881 | June 15, 16. | 69 33.5 | 4.615 |
| Snead, yard of Snead's house. | 37 58.3 | 75 26.2 | 1856 | Sept. 2. | 70 31.0 | 4.448 |
| Charlottesville. | 38 02 | 78 30 | 1834 | ---- | 71 09 | ---- |
| Do. | 38 01.0 | 78 31 | 1873 | July 16. | 70 20.0 | 4.428 |
| Staunton, on hill. | 38 08.9 | 79 04 | 1873 | Sept. 1. | 69 54.1 | 4.489 |
| Fredericksburg, Brown's Island. | 38 18.2 | 77 27.4 | 1856 | Sept. 17. | 70 37.9 | 4.449 |
| Clark Mountain. | 38 18.6 | 78 00.2 | 1871 | Aug. 29; Sept. 1. | 71 40.2 (?) | 4.390 |
| Harrisonburg. | 38 25 | 78 52 | 1873 | Sept. 2. | 70 28.9 | 4.437 |
| Culpeper. | 38 28.5 | 78 00 | 1873 | July 14. | 70 42.0 | 4.492 |
| Mount Vernon. | 38 42.5 | 77 05.3 | 1844 | Apr. 11. | 70 55.5 | 4.401 |
| Bull Run. | 38 52.8 | 77 42.3 | 1871 | Oct. 18; Nov. 6. | 71 18.9 | 4.334 |
| Peach Grove. | 38 55.2 | 77 13.8 | 1869 | Oct. Nov. | 71 05.0 | 4.346 |
| Strasburg, opposite Kelley's house. | 38 59.5 | 78 21.6 | 1873 | July 12. | 70 56.2 | 4.375 |

WASHINGTON TERRITORY.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Fort Vancouver. | 45 37.5 | 122 39.5 | 1830 | Nov. | 69 39.7 | 4.442 |
| Fort Vancouver, room and garden. | 45 37.5 | 122 39.5 | 1839 | ---- | 69 22.2 | 4.475 |
| Fort Vancouver. | 45 37.5 | 122 39.5 | 1860 | May 3. | 69 17.4 | 4.6180 |
| Vancouver. | 45 37.5 | 122 39.5 | 1881 | Oct. 26, 27. | ---- | 4.547 |
| Lower Cascades, Rapids of Columbia River. | 45 40 | 121 50 | 1830 | ---- | 69 27 | 4.442 |
| Lower Cascades. | 45 39 | 122 00 | 1881 | Oct. 22, 23. | ---- | 4.496 |
| Dalles, eight-mile camp north side of Columbia River. | 45 40 | 120 49 | 1860 | June 1. | 70 04.5 | ---- |
| Walla-Walla, town. | 46 03.9 | 118 20.5 | 1881 | Sept. 25, 26. | 70 46.5 | 4.349 |
| Walla-Walla River, near Old Fort. | 46 03 | 118 50 | 1830 | July. | 70 14 | 4.349 |
| Wallula, near old Fort Walla-Walla. | 46 07 | 118 55 | 1881 | Sept. 29, 30; Oct. 1. | 70 24.9 | 4.391 |
| Dry Creek. | 46 09 | 118 18 | 1861 | ---- | 70 49 | 4.290 |
| Ainsworth, southwest of southern house of town. | 46 14 | 119 03 | 1881 | Aug. 22, 23. | 70 37.8 | 4.332 |
| Cape Disappointment. | 46 16.5 | 124 02 | 1830 | Sept. and Dec. | 69 30.3 | 4.436 |
| Cape Disappointment, Baker's Bay, landing place. | 46 17 | 124 03 | 1839 | ---- | 69 26.9 | 4.394 |
| Cape Disappointment, on beach. | 46 16.7 | 124 02.8 | 1873 | Oct. 22–30. | 69 13.7 | 4.537 |
| Do. | 46 16.7 | 124 02.8 | 1881 | Oct. 13–15. | 69 17.7 | 4.482 |

*ntensities in the United States and adjacent regions.—Continued.*

VIRGINIA—Continued.

| Total force F. | Referred results. $\theta_{1885\cdot0}$ | $H_{1885\cdot0}$ | $F_{1885\cdot0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| 13.34 | 69.20 | 4.694 | 13.22 | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 69.24 | 4.648 | 13.11 | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| 13.35 | 69.75 | 4.573 | 13.21 | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.40 | 69.68 | 4.596 | 13.23 | A. T. Mosman. | Do. |
| ---- | 69.34 | 4.629 | 13.12 | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| 13.21 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.34 | 69.92 | 4.533 | 13.21 | C. A. Schott. | Do. |
| ---- | ---- | ---- | ---- | Patterson, | Sill. J., 1838. E. Loomis. |
| ---- | 69.86 | 4.474 | 12.99 | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| ---- | 69.43 | 4.535 | 12.91 | Do. | Do. |
| 13.42 | 70.03 | 4.534 | 13.27 | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.96 | ---- | 4.444 | ---- | C. O. Boutelle. | Do. |
| ---- | 70.01 | 4.482 | 13.11 | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| ---- | 70.23 | 4.537 | 13.42 | Do. | Do. |
| 13.47 | 70.41 | 4.459 | 13.30 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.53 | 70.81 | 4.388 | 13.35 | C. O. Boutelle. | C. & G. S. Rpt., 1881, App. 9. |
| 13.41 | 70.54 | 4.407 | 13.23 | Do. | Do. |
| ---- | 70.47 | 4.421 | 13.23 | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14. Nat. Acad. Ser. |

WASHINGTON TERRITORY.

| Total force F. | $\theta_{1885\cdot0}$ | $H_{1885\cdot0}$ | $F_{1885\cdot0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 12.78 | | | | D. Douglas. | Rpt. Brit. Asso., Vol. VI, London, 1838, and C. S. Rpt., 1861, App. 22. |
| 12.60 | 69.2 | 4.49 | 12.64 | E. Belcher. | Phil. Trans. R. S., 1841 & 1843. |
| 13.052 | | | | R. W. Haig. | Phil. Tran. R. S., 1864, Bound. Com, Capt. R. W. Haig, R. A. θ, H & F obs'd. |
| ---- | | | | J. S. Lawson. | C. & G. S. Rpt., 1881, App. 9. |
| 12.66 | ---- | 4.44 | ---- | D. Douglas. | Rpt. Brit. Asso., Vol. VI, London, 1838. |
| ---- | ---- | 4.488 | ---- | J. S. Lawson. | C. & G. S. Rpt., 1881, App. 9. |
| 13.003 | 70.1 | 4.37 | 12.84 | R. W. Haig. | B. S. Phil. Trans. R. S., 1864. |
| 13.21 | 70.7 | 4.341 | 13.13 | J. S. Lawson. | C. & G. S. Rpt., 1881, App. 9. |
| 12.87 | ---- | ---- | ---- | D. Douglas. | Rpt. Brit. Asso., Vol. VI., London, 1838. |
| 13.10 | 70.4 | 4.383 | 13.07 | J. S. Lawson. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 70.8 | 4.23 | 12.86 | J. S. Harris. | U. S. N. W. Bound. Com.; MS. in C. & G. S. Office. |
| 13.06 | 70.6 | 4.328 | 13.03 | J. S. Lawson. | C. & G. S. Rpt., 1881, App. 9. |
| 12.67 | | | | D. Douglas. | Rpt. Brit. Asso., Vol. VI, London, 1838, and C. S. Rpt., 1861, App. 22. |
| 12.52 | 69.2 | 4.490 | 12.64 | E. Belcher. | Do. |
| 12.79 | | | | W. Eimbeck. | C. & G. S. Rpt., 1881, App. 9. |
| 12.68 | | | | H. E. Nichols. | Do. |

**Table I.—*Observed magnetic dips and horizontal and total magnetic***

WASHINGTON TERRITORY—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Pomeroy, northeast corner Main and Second streets. | 46 31 | 117 40 | 1881 | Sept. 20. | 70 20.2 | 4.406 |
| Tukannon River. | 46 32 | 118 00 | 1861 | ---- | 70 23 | 4.382 |
| Sixty Mile Well, on ridge, west side of coulée. | 46 49 | 118 50 | 1881 | Aug. 25. | 70 44.8 | 4.321 |
| Cow Creek. | 46 53 | 118 10 | 1861 | ---- | 71 57 | 4.302 |
| Olympia, on block between Union and Eleventh and Columbus and Main streets. | 47 02.3 | 122 54.0 | 1881 | Nov. 4. | ---- | 4.283 |
| Nisqually. | 47 07 | 122 38 | 1859 | Jan. 31. | 70 40.0 | ---- |
| Lugenbeel's Creek. | 47 09 | 118 06 | 1861 | ---- | 71 20 | 4.230 |
| Sprague, west of railroad track. | 47 19 | 118 10 | 1881 | Aug. 27, 28. | 71 05.8 | 4.299 |
| Seattle, edge of bluff, bank of Duwamish Bay. | 47 35.9 | 122 20.0 | 1871 | Sept. 21; Oct. 4, 5. | 71 08.9 | 4.252 |
| Seattle. | 47 35.9 | 122 20.0 | 1881 | Nov. 10, 11. | ---- | 4.217 |
| Spokane Falls, on Wolverton's place. | 47 43 | 117 23 | 1881 | Aug. 30. | 72 13.3 | 4.170 |
| Peon's Prairie. | 47 44 | 117 14 | 1861 | ---- | 72 07 | 4.100 |
| Spokane Ferry. | 47 49 | 117 49 | 1861 | ---- | 71 53 | 4.133 |
| Chemikane. | 48 00 | 117 45 | 1861 | May 19. | 72 04.2 | ---- |
| Port Discovery. | 48 02 | 122 50 | 1792 | May. | 74 30 | ---- |
| Okinakane (Oakanagan). | 48 05 | 119 27 | 1833 | April. | 71 45 | 4.033 |
| Port Townsend. | 48 07.0 | 122 45.0 | 1881 | Nov. 17, 18. | ---- | 4.144 |
| Scarborough Harbor. | 48 21.8 | 124 38.0 | 1852 | Sept. 7, 8. | ---- | 4.170 |
| Nee-ah Bay, near Waddah Island. | 48 22 | 124 36.8 | 1855 | Aug. 13–22. | 71 07.0 | 4.276 |
| Nee-ah Bay. | 48 21.8 | 124 38.0 | 1881 | Oct. 10, 11. | 71 04.4 | 4.144 |
| Colville Depot. | 48 34 | 117 52 | 1861 | ---- | 72 31 | 3.976 |
| Fort Colville, old B. B. C. Barracks. | 48 40 | 118 05 | 1861 | Mar. 26; Apr. 23. | 72 41.9 | 3.9923 |
| Birch Bay. | 48 53 | 122 45 | 1792 | June. | 73 13 | ---- |
| Point Roberts. | 48 59 | 123 01 | 1858 | March. | 71 42.6 | 4.112 |
| Semi-ah-moo Spit. | 48 59.4 | 122 46.2 | 1858 | ---- | 72 15 | ---- |
| Skagit. | 49 00 | 121 03 | 1860 | ---- | 72 39 | 3.933 |
| Camp Osogoos. | 49 00 | 119 24 | 1861 | ---- | 72 35 | ---- |

WEST VIRGINIA.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Alderson, southwest part of town. | 37 45 | 80 40 | 1881 | June 11, 13. | 69 25.9 | 4.679 |
| Charleston, on road leading to ferry. | 38 21.0 | 81 38.1 | 1881 | June 6, 7. | 69 57.2 | 4.577 |
| Parkersburg, foot of Court street, on bluff. | 39 16.0 | 81 34 | 1881 | May 30, 31. | 70 58.6 | 4.402 |
| Clarksburg, near academy. | 39 16.9 | 80 20.4 | 1880 | Dec. 10, 11. | 70 44.8 | 4.413 |
| Martinsburg, grounds of Randolph's house. | 39 26.7 | 77 57 | 1873 | July 10. | 71 25.1 | 4.231 |
| Wheeling. | 40 05 | 80 43 | 1840 | Aug. | 72 08.9 | 4.053 |
| Do. | 40 05 | 80 44 | 1844 | Mar. 24. | 72 19.3 | 4.164 |
| Do. | 40 05 | 80 44 | 1845 | Apr. 30. | 72 13.7 | 4.176 |
| Wheeling, south end of Zane's Island. | 40 03.3 | 80 44 | 1881 | May 25, 26. | 71 54.5 | 4.208 |

*intensities in the United States and adjacent regions.—Continued.*

WASHINGTON TERRITORY—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 13.09 | ° 70.3 | 4.398 | 13.05 | J. S. Lawson. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 70.4 | 4.32 | 12.88 | J. S. Harris. | U. S. N. W. Bound. Com.; MS. in C. & G. S. Office. |
| 13.10 | 70.7 | 4.313 | 13.05 | J. S. Lawson. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | (71.9) | 4.24 | (13.65) | J. S. Harris. | U. S. N. W. Bound. Com.; MS. in C. & G. S. Office. |
| ---- | ---- | 4.275 | ---- | J. S. Lawson. | C. & G. S. Rpt., 1881, App. 9. |
| 13.116 | 70.7 | 4.28 | 12.95 | R. W. Haig. | B. S. Phil. Trans. R. S., 1864. |
| ---- | 71.3 | 4.17 | 13.01 | J. S. Harris. | U. S. N. W. Bound. Com.; MS. in C. S. Office. |
| 13.27 | 71.0 | 4.291 | 13.18 | J. S. Lawson. | C. & G. S. Rpt., 1881, App. 9. |
| 13.16 | } 71.1 | 4.210 | 13.00 { | S. R. Throckmorton. | Do. |
| ---- | | | | J. S. Lawson. | Do. |
| 13.66 | 72.2 | 4.162 | 13.61 | Do. | Do. |
| ---- | 72.1 | 4.04 | 13.14 | J. S. Harris. | U. S. N. W. Bound. Com.; MS. in C. & G. S. Office. |
| ---- | 71.9 | 4.08 | 13.13 | Do. | Do. |
| 13.343 | 72.1 | 4.05 | 13.18 | R. W. Haig. | B. S. Phil. Trans. R. S., 1864. |
| ---- | ---- | ---- | ---- | G. Vancouver. | A voyage of discovery, by G. Vancouver, 3 vols., London, 1798. |
| 12.88 | ---- | 4.03 | ---- | D. Douglas. | Rpt. Brit. Asso., Vol. VI, London, 1838. |
| ---- | ---- | 4.136 | ---- | J. S. Lawson. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | G. Davidson and J. Rockwell. | Do. |
| 13.21 | 71.07 | 4.147 | 12.78 | W. P. Trowbridge. | Do. |
| 12.78 | | | | H. E. Nichols. | Do. |
| ---- | 72.5 | 3.92 | 13.04 | J. S. Harris. | U. S. N. W. Bound. Com.; MS. in C. & G. S. Office. |
| 13.397 | 72.7 | 3.93 | 13.22 | R. W. Haig. | B. S. Phil. Trans. R. S., 1864. θ, H & F obs'd. |
| ---- | ---- | ---- | ---- | G. Vancouver. | A voyage of discovery by G. Vancouver, 3 vols., London, 1798. |
| ---- | 71.7 | 4.05 | 12.90 | J. S. Harris. | U. S. N. W. Bound. Com.; MS. in C. & G. S. Office. |
| ---- | 72.2 | ---- | ---- | Richards. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| ---- | 72.6 | 3.88 | 12.98 | J. S. Harris. | U. S. N. W. Bound. Com.; MS. in C. & G. S. Office. |
| ---- | 72.6 | ---- | ---- | Do. | Do. |

WEST VIRGINIA.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 13.32 | 69.24 | 4.692 | 13.24 | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.35 | 69.76 | 4.590 | 13.27 | Do. | Do. |
| 13.50 | 70.79 | 4.415 | 13.40 | Do. | Do. |
| 13.38 | 70.54 | 4.428 | 13.29 | Do. | Do. |
| ---- | 70.95 | 4.277 | 13.11 | F. E. Hilgard and J. M. Poole. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| ---- | | | | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| 13.72 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | 71.71 | 4.227 | 13.47 | Do. | Phil. Trans. R. S., 1846 and Smithsonian Cont's to Know., Vol. III, 1852. |
| 13.55 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

WISCONSIN.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Platteville, south of village. | 42 43 | 90 14 | 1841 | Sept. | 73 17.4 | ---- |
| Mineral Point. | 42 50 | 89 54 | 1839 | Nov. 5. | 73 20.6 | 3.953 |
| Mineral Point, west of Franklin House. | 42 50 | 89 54 | 1841 | Sept. | 73 23.2 | ---- |
| Hickok's, 10 miles from Blue Mounds. | 42 58 | 90 00 | 1841 | Sept. | 73 39.5 | ---- |
| Blue Mounds. | 43 01.5 | 89 51 | 1839 | Oct. 29. | 73 41 | 3.887 |
| Blue Mounds, near E. Brigham's. | 43 01.5 | 89 51 | 1841 | Sept. | 73 34.9 | ---- |
| Campbell's, 10 miles from Blue Mounds. | 43 01 | 89 40 | 1841 | Sept. | 73 28.1 | ---- |
| Milwaukee, corner Fourth and Poplar streets. | 43 02.8 | 87 55.1 | 1859 | Aug. 20. | 73 57 | 3.858 |
| Milwaukee, Spring street, between Fourth and Fifth streets. | 43 02.8 | 87 55.1 | 1873 | Aug. 22. | 73 43 | 3.897 |
| Prairie du Chien. | 43 03 | 96 01 | 1839 | Oct. 24. | 73 16.6 | 3.988 |
| Madison, southeast of capitol. | 43 04.0 | 89 22.5 | 1839 | Nov. 2. | {74 04.4<br>74 03.0 | } 3.878 |
| Do. | 43 04.0 | 89 22.5 | 1841 | Sept. | 74 06.5 | ---- |
| Madison, Magnetic Observatory, grounds of University. | 43 04.5 | 89 24.2 | 1876 | Oct. 3, 17. | 73 54.8 | 3.891 |
| Do. | 43 04.5 | 89 24.2 | 1877 | Aug. & Sept. | 73 55.5 | 3.913 |
| Madison, University Station. | 43 04.5 | 89 24.2 | 1878 | Aug. 29, 30. | ---- | 3.903 |
| Madison, Observatory and South Stations. | 43 04.5 | 89 24.2 | 1878 | Sept. 8–15. | 73 56.5 | 3.899 |
| Madison, Observatory and Farm Station. | 43 04.5 | 89 24.8 | 1878 | Nov. 21, 26. | 73 55.1 | 3.894 |
| Madison, Observatory, South and Farm Stations. | 43 04.5 | 89 24.5 | 1879 | Sept. 23; Oct. 9. | 73 50.5 | 3.908 |
| Madison, Observatory and Farm Station. | 43 04.5 | 89 24.8 | 1880 | Sept. 15–25. | 73 47.0 | 3.903 |
| Madison, University and Farm Station. | 43 04.5 | 89 25.2 | 1881 | Dec. 16–19. | 73 48.1 | 3.898 |
| La Crosse, near Main Street Park. | 43 48.8 | 91 15.1 | 1876 | Sept. 18–22. | 73 57.2 | 3.8443 |
| La Crosse, Court-House Square. | 43 48.8 | 91 14.8 | 1877 | Sept. 24, 25, 26. | 73 48.7 | 3.880 |
| Superior City, near Robbins' house. | 46 43 | 92 04 | 1870 | Sept. 20. | 76 28 | 3.227 |
| Superior City, Fourth street near Becker avenue | 46 40 | 92 04 | 1880 | Aug. 21, 23. | 76 26.1 | 3.261 |
| La Pointe. | 46 47 | 90 58 | 1843 | July 21. | 76 56 | 3.206 |

WYOMING.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Sherman. | 41 07.8 | 105 23.6 | 1872 | Aug. 3, 5, 6. | 68 53.3 | 4.768 |
| Cheyenne. | 41 07 | 104 49 | 1872 | Oct. 22. | 68 58.1 | 4.705 |
| Cheyenne, between court and school houses. | 41 07.8 | 104 48.9 | 1878 | Aug. 9. | 69 02.0 | 4.7348 |
| Cheyenne, corner Seventeenth and Dodge streets. | 41 08 | 104 49.0 | 1878 | Sept. 13–17. | 68 54.4 | 4.738 |
| Fort Bridger. | 41 20 | 110 24 | 1858–9 | ---- | 68 05 | ---- |
| Green River, opposite court-house. | 41 31.6 | 109 28.2 | 1878 | Aug. 26. | 68 20.5 | 4.8069 |
| Green River, south of station house. | 41 32 | 109 29 | 1878 | Oct. 5–10. | 68 17.1 | 4.813 |
| Fort Fred. Steele, south of army hospital. | 41 46.7 | 106 56.8 | 1878 | Sept. 26–29. | 69 00.2 | 4.707 |
| Fort Laramie. | 42 12 | 104 31 | 1858–7 | ---- | 70 03 | ---- |

*intensities in the United States and adjacent regions.—Continued.*

WISCONSIN.

| Total force F. | Referred results. $\theta_{1885.0}$ | Referred results. $H_{1885.0}$ | Referred results. $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| ---- | 72.9° | ---- | ---- | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| 13.79 | 73.0 | 3.96 | 13.55 | J. Locke. | Sill. Jour., 1840, and Trans. Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | | | | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | 73.3 | ---- | ---- | Do. | Do. |
| 13.84 | 73.3 | 3.90 | 13.57 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | | | | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| ---- | 73.1 | ---- | ---- | Do. | Do. |
| 13.956 | 73.48 | 3.90 | 13.72 | W. P. Smith. | U. S. Lake Survey, Capt. G. G. Meade, Detroit, 1859, and C. B. Comstock, 1882. |
| 13.900 | | | | A. N. Lee. | U. S. Lake Survey, Genl. C. B. Comstock, MS. 1873, and Rpt. of 1882. |
| 13.87 | 72.9 | 4.00 | 13.60 | J. Locke. | Sill. J., Vol. XXXIX, 1840, E. Loomis, and Trans. Am. Phil. Soc., 1846, Art. XI. |
| 14.11 | 72.69 | 3.907 | 13.91 | Do. | Sill. J., Vol. XXXIX, 1840, and Trans. Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| ---- | | | | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| 14.04 | | | | F. E. Hilgard. | C. & G. S. Rpt., 1881, App. 9. |
| 14.13 | | | | A. Braid. | Do. |
| ---- | | | | G. Hinrichs. | MS. in C. & G. S. Office. |
| 14.095 | | | | W. Suess. | C. & G. S. Rpt., 1881, App. 9. |
| 14.045 | | | | J. B. Baylor. | Do. |
| 14.04 | | | | D. Mason. | Do. |
| 13.98 | | | | Do. | Do. |
| 13.97 | | | | W. Suess. | Do. |
| 13.907 | 73.63 | 3.87 | 13.73 | C. F. Powell. | Rpt. Chief of Engineers, U. S. A., for 1877, Part 2. |
| 13.92 | | | | A. Braid. | C. & G. S. Rpt., 1881, App. 9. |
| 13.790 | 76.17 | 3.26 | 13.64 | C. B. Comstock. | U. S. Lake Survey, MS. 1875, & C. B. Comstock's Rpt., 1882. |
| 13.90 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 14.18 | 76.6 | 3.22 | 13.89 | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |

WYOMING.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 13.24 | 68.9 | 4.77 | 13.25 | W. Suess and R. D. Cutts. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 68.9 | 4.74 | 13.17 | T. C. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. |
| 13.232 | | | | T. E. Thorpe. | Proc. R. S., No. 200, 1880. |
| 13.16 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | ---- | ---- | ---- | J. H. Simpson. | Mag. Var. by J. B. Stone, New York, 1878. |
| 13.024 | 68.3 | 4.81 | 13.01 | T. E. Thorpe. | Proc. R. S., No. 200, 1880. |
| 13.01 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 13.14 | 69.0 | 4.71 | 13.14 | Do. | Do. |
| ---- | ---- | ---- | ---- | J. H. Simpson. | Mag. Var. by J. B. Stone, New York, 1878. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

WYOMING—Continued.

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Little Sandy Creek. | 42 15 | 109 40 | 1858.8 | ---- | 69 00 | ---- |
| Sweetwater River. | 42 30 | 108 35 | 1858.8 | ---- | 69 35 | ---- |
| La Banta River. | 42 35 | 105 22 | 1858.8 | ---- | 70 15 | ---- |
| Sweetwater River. | 42 38 | 107 25 | 1858.8 | ---- | 69 53 | ---- |
| Greasewood Creek. | 42 40 | 107 07 | 1858.8 | ---- | 70 01 | ---- |
| West of Deer Creek. | 42 53 | 105 57 | 1858.8 | ---- | 70 29 | ---- |
| Mile-post 42. | 44 59.8 | 110 11.6 | 1882 | Aug. 16. | 71 17.5 | 4.303 |
| Northeast corner of Wyoming Territory. | 44 59.9 | 104 03.0 | 1882 | June 7. | 72 41.0 | 4.096 |
| Little Missouri River station. | 44 59.9 | 104 24.6 | 1882 | June 24. | 72 43.7 | 4.124 |
| Mile-posts 283, 284. | 45 00.0 | 105 20.2 | 1882 | July 7. | 72 14.0 | 4.207 |
| Mile-post 185. | 45 00.4 | 107 21.0 | 1882 | July 16. | 72 10.4 | 4.198 |

DOMINION OF CANADA,

[To longitude 75° west.]

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Yarmouth, Nova Scotia. | 43 49.9 | 66 07.2 | 1881 | Nov. 7, 8. | 74 35 | 3.474 |
| Weymouth, Nova Scotia. | 44 24.4 | 65 59.8 | 1881 | Nov. 10. | 74 45 | 3.461 |
| Halifax, Nova Scotia, Dock-yard Observatory. | 44 39 | 63 37 | 1834 | May 27. | 75 33 | } 3.22 |
| Do. | 44 39 | 63 37 | 1837 | June 7. | 74 58 | |
| Do. | 44 39 | 63 37 | 1838.5 | ---- | 74 45 | ---- |
| Do. | 44 39 | 63 36 | 1847.5 | ---- | 75 37 | ---- |
| Halifax, Nova Scotia, drill-ground, Dock-yard. | 44 39.8 | 63 35.2 | 1873 | May 13, 15, 16. | 74 48.2 | 3.385 |
| Halifax, Nova Scotia, Dock-yard. | 44 39.5 | 63 35.0 | 1879 | Sept. 8–10. | 74 39.2 | 3.452 |
| Do. | 44 39.5 | 63 35 | 1881 | Nov. 2. | 74 29 | 3.459 |
| Annapolis, Nova Scotia. | 44 44.5 | 65 31.1 | 1881 | Nov. 14, 15. | 74 53 | 3.428 |
| Windsor, Nova Scotia. | 44 59.6 | 64 08.4 | 1881 | Nov. 21, 22. | 74 49 | 3.423 |
| Do. | 45 10 | 64 16 | 1847 | ---- | 75 41 | ---- |
| Lake Memphremagog, East shore. | 45 01 | 72 15 | 1845 | ---- | 76 08.6 | ---- |
| Stanstead, Q., garden of hotel, near Anglican Church. | 45 02 | 72 07 | 1842 | Sept. 12. | 76 19.2 | 3.222 |
| Cornwall, orchard behind Chesley's Inn. | 45 02 | 74 50 | 1845 | June 16. | 76 16.4 | ---- |
| Chamcook. | 45 07.5 | 67 04.9 | 1859 | Oct. 13, 17, 20. | 76 09.4 | 3.241 |
| Kentville, Nova Scotia. | 45 12 | 64 46 | 1847 | ---- | 75 46 | ---- |
| St. John, New Brunswick. | 45 14 | 66 03 | 1847 | ---- | 75 56 | ---- |
| St. John's, Q., behind hotel, ¼ mile above bridge. | 45 17 | 73 15 | 1842 | Sept. 14. | 77 00.1 | ---- |
| Isle d'Urval, opposite La Chine. | 45 25.0 | 73 44 | 1843 | Apr. 30. | 77 03.1 | ---- |
| Isle Madame, Cape Breton Island. | 45 28 | 61 03 | 1862 | ---- | 75 31 | ---- |
| Arichat, Isle Madame, Nova Scotia. | 45 30.5 | 61 01.3 | 1881 | Oct. 26. | 74 43 | 3.435 |
| Montreal. | 45 31 | 73 30 | 1833 | ---- | 77 06 | ---- |
| Do. | 45 30 | 73 33 | 1838 | ---- | 76 19 | ---- |
| Montreal, St. Helen's Isle, near Artillery Barracks. | 45 31 | 73 32 | 1842 | Sept. 16. | 77 13.1 | 3.064 |

***intensities in the United States and adjacent regions.*—*Continued.***

WYOMING—Continued.

| Total force F. | Referred results. $\theta_{1885,0}$. | $H_{1885,0}$ | $F_{1885,0}$. | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| ---- | ---- | ---- | ---- | J. H. Simpson. | Mar. Var. by J. B. Stone, New York, 1878. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| 13.416 | 71.27 | 4.303 | 13.40 | B. A. Colonna. | MS. record in C. & G. S. Office. |
| 13.762 | 72.66 | 4.096 | 13.74 | Do. | Do. |
| 13.889 | 72.71 | 4.124 | 13.88 | Do. | Do. |
| 13.788 | 72.21 | 4.207 | 13.77 | Do. | Do. |
| 13.712 | 72.15 | 4.198 | 13.69 | Do. | Do. |

DOMINION OF CANADA,

[To longitude 75° west.]

| Total force F. | $\theta_{1885,0}$. | $H_{1885,0}$ | $F_{1885,0}$. | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 13.07 | 74.28 | 3.486 | 12.87 | S. W. Very. | C. & G. S. Rpt., 1881, App. 9. |
| 13.16 | 74.45 | 3.473 | 12.96 | Do. | Do. |
| 12.94 | | | | E. Home. | Phil. Trans. R. S., 1838, Pt. I, Capt. Sir E. Home. |
| | | | | Do. | Do. |
| ---- | | | | Estcourt. | Phil. Trans. R. S., 1872, E. Sabine. |
| 13.07 | 74.22 | 3.460 | 12.72 | Keely. | Do. |
| 12.914 | | | | Maclear and Bromley. | Voy. of H. M. S. Challenger, Capt. G. S. Nares, Vol. II, London, 1882. |
| 13.04 | | | | J. B. Baylor. | C. & G. S. Rpt., 1881, App. 9. |
| 12.93 | | | | S. W. Very. | Do. |
| 13.14 | 74.58 | 3.440 | 12.94 | Do. | Do. |
| 13.07 | 74.65 | 3.435 | 12.98 | Do. | Do. |
| ---- | | | | G. W. Keely. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| ---- | 75.27 | ---- | ---- | A. W. Whipple. | Phil. Trans. R. S., 1846. |
| 13.624 | 75.45 | 3.270 | 13.02 | J. H. Lefroy. | Diary Mag. Sur., Canada, Gen. Sir J. H. Lefroy, London, 1883. |
| 13.789 | 75.40 | 3.340 | 13.25 | C. Younghusband. | Do. |
| 13.54 | 75.16 | 3.363 | 13.13 | G. W. Dean and A. D. Bache. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 74.87 | ---- | ---- | G. W. Keely. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| ---- | 75.04 | ---- | ---- | Do. | Do. |
| ---- | 76.13 | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur., Canada, Gen. Sir J. H. Lefroy, London, 1883. |
| 13.643 | 76.18 | 3.110 | 13.02 | Do. | Do. |
| ---- | 74.48 | 3.447 | 12.88 | Shadwell. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| 13.03 | | | | S. W. Very. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | Back. | Sill. J., Vol. XXXIX, 1840, E. Loomis. |
| ---- | | | | Estcourt. | Phil. Trans. R. S., 1840. |
| 13.720 | | | | J. H. Lefroy. | Diary Mag. Sur., Canada, Gen. Sir J. H. Lefroy, London, 1883. $\theta$, H, and F. obs'd. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

DOMINION OF CANADA—Continued.

[To longitude 75° west.]

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Montreal, St. Helen's Isle, Artillery Barracks. | 45 31 | 73 32 | 1843 | Apr. 25, 29. | 77 08.8 | ---- |
| Montreal. | 45 31 | 73 32 | 1843 | Aug. | ---- | 3.109 |
| Montreal, garden, foot of mountain. | 45 31 | 73 33.3 | 1845 | June 20. | 77 08.5 | ---- |
| Montreal, grounds of McGill University. | 45 30.5 | 73 34.9 | 1859 | July 20. | 76 51.4 | 3.111 |
| Do. | 45 30.5 | 73 34.9 | 1879 | Sept. 25. | 76 25.7 | 3.191 |
| La Combe's farm. | 45 33 | 74 09 | 1843 | May 2. | 76 50.6 | ---- |
| Pointe du Chene, left bank. | 45 37 | 74 50 | 1843 | May 3. | 76 55.4 | ---- |
| Richmond Junction, P. Q. | 45 41 | 72 03 | 1876 | Aug. 15. | 75 47.7 | 3.380 |
| Kingsey, Q., in garden of Captain Cox. | 45 46 | 72 12 | 1842 | Sept. 10. | 77 40.0 | ---- |
| Louisburg. | 45 53 | 60 00 | 1862 | ---- | 76 00 | ---- |
| Fredericton, New Brunswick. | 45 55 | 66 38.2 | 1847 | ---- | 76 59 | ---- |
| Sorel, east of Roman Catholic church. | 46 02 | 73 03 | 1842 | Sept. 8. | 77 16.4 | ---- |
| Sydney, Cape Breton, Nova Scotia. | 46 08.6 | 60 11.6 | 1881 | Oct. 21, 22. | 75 10 | 3.286 |
| Woodstock, New Brunswick. | 46 09 | 67 35 | 1847 | ---- | 77 05 | ---- |
| Cape Breton. | 46 16 | 60 08 | 1862 | ---- | 76 03 | ---- |
| Three Rivers, garden of Mr. Bell. | 46 21 | 72 32 | 1842 | Sept. 6. | 77 10.7 | ---- |
| Becancour, Province of Quebec. | 46 22 | 71 33 | 1876 | Aug. 17, 18. | 76 54.5 | 3.118 |
| St. Pierre de Miquelon, Gulf of St. Lawrence. | 46 46.9 | 56 10.6 | 1872 | June 20–29. | 74 37.9(?) | 3.193 |
| Do. | 46 46.8 | 56 10.6 | 1881 | Oct. 11–14. | 75 02 | 3.255 |
| Quebec: | | | | | | |
| In 1842, near artillery barracks. | 46 49.5 | 71 14.2 | 1842 | Sept. 1. | 77 15.3 | } 3.040 |
| In 1845, near Wolfe and Montcalm monuments. | 46 48.6 | 71 13.3 | 1845 | June 23. | 77 08.8 | |
| Quebec, near Wolfe's Monument. | 46 48.4 | 71 14.5 | 1859 | July 18, 19. | 77 17.5 | 2.991 |
| Do. | 46 48.4 | 71 14.5 | 1879 | Sept. 16, 19. | 76 45.1 | 3.104 |
| St. Thomas, Province of Quebec. | 46 59 | 70 33 | 1876 | Aug. 24, 25. | 77 11.7 | 3.024 |
| Edmonston, New Brunswick. | 47 15 | 68 20 | 1876 | Aug. 31. | 77 18.3 | 2.970 |
| St. John's, Newfoundland, grounds about Government house. | 47 34.4 | 52 41.9 | 1881 | Sept. 26, 27, 28. | 74 37 | 3.300 |
| St. John's, Newfoundland, old cemetery on Church Hill. | 47 34.5 | 52 42 | 1883 | June 28. | 74 47 | 3.292 |
| Riviere du Loup-en-bas, Province of Quebec. | 47 51 | 69 25 | 1876 | Aug. 28–30. | 77 31.6 | 2.947 |
| Brandypot Island, St. Lawrence River. | 47 53 | 69 42 | 1830 | ---- | 78 35 | ---- |
| Gaspe Basin, Gulf of St. Lawrence. | 48 50 | 64 30 | 1832 | ---- | 78 50 | ---- |
| Twillingate, Newfoundland. | 49 39.2 | 54 46.2 | 1881 | July 9–16. | 75 57 | 3.050 |
| Battle Harbor, Caribou Islands, Labrador. | 52 16.3 | 55 34.5 | 1881 | Sept. 6, 7, 8, 9. | 77 16 | 2.770 |

*intensities in the United States and adjacent regions.—Continued.*

DOMINION OF CANADA—Continued.

[To longitude 75° west.]

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| 13.762 | 76.05 | 3.200 | 13.27 | J. H. Lefroy. | Diary Mag. Sur., Canada, Gen. Sir J. H. Lefroy, London, 1883. |
| 13.62 | | | | A. D. Bache. | C. S. Rpt., 1861, App. 22. |
| 13.536 | | | | C. Younghusband. | Diary Mag. Sur., Canada, Gen. Sir J. H. Lefroy, London, 1883. |
| 13.68 | | | | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.60 | | | | J. B. Baylor. | Do. |
| 13.855 | 75.97 | 3.205 | 13.22 | J. H. Lefroy. | Diary Mag. Sur., Canada, Gen. Sir J. H. Lefroy, London, 1883. |
| 13.622 | 76.05 | 3.133 | 13.00 | Do. | Do. |
| ---- | 75.15 | 3.412 | 13.31 | F. E. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected.—Sch.] |
| 13.687 | 76.80 | 2.971 | 13.01 | J. H. Lefroy. | Diary Mag. Sur., Canada, Gen. Sir J. H. Lefroy, London, 1883. |
| ---- | 75.01 | ---- | ---- | Shadwell. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| ---- | 76.09 | ---- | ---- | G. W. Keely. | Do. |
| 13.751 | 76.40 | 3.076 | 13.08 | J. H. Lefroy. | Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883. |
| 12.84 | 74.87 | 3.298 | 12.64 | S. W. Very. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 76.19 | ---- | ---- | G. W. Keely. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| ---- | 75.06 | ---- | ---- | Shadwell. | Do. |
| 13.843 | 76.31 | 3.119 | 13.18 | J. H. Lefroy. | Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883. |
| ---- | 76.26 | 3.150 | 13.26 | F. E. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected.—Sch.] |
| 12.05 (?) | 74.73 | 3.256 | 12.36 | E. Goodfellow. | C. & G. S. Rpt., 1881, App. 9. |
| 12.60 | | | | S. W. Very. | Do. |
| 13.702 | 76.31 | 3.111 | 13.15 | J. H. Lefroy and C. Younghusband. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. $\theta$, H, & F obs'd. |
| 13.60 | | | | C. A. Schott. | C. & G. S. Rpt., 1881, App. 9. |
| 13.54 | | | | J. B. Baylor. | Do. |
| ---- | 76.56 | 3.056 | 13.15 | F. E. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected.—Sch.] |
| ---- | 76.66 | 3.002 | 13.01 | Do. | Do. |
| 12.44 | 74.47 | 3.328 | 12.43 | S. W. Very. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | | | | W. H. Lamar and F. W. Ellis. | U. S. Signal Corps, Service Notes XIV, Wash., 1884. |
| ---- | 76.89 | 2.979 | 13.13 | F. E. Hilgard. | C. & G. S. Rpt., 1882, App. 14, Nat. Acad. Ser. [Corrected.—Sch.] |
| ---- | 77.58 | ---- | ---- | Bayfield. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| ---- | 77.90 | ---- | ---- | Do. | Do. |
| 12.56 | 75.63 | 3.062 | 12.34 | S. W. Very. | C. & G. S. Rpt., 1881, App. 9. |
| 12.57 | 76.95 | 2.782 | 12.32 | Do. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

DOMINION OF CANADA.—Continued.

[Between longitudes 75° and 90° west.]

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Amherstburg, C. W., Mr. Gordon's garden. | 42 06 | 83 03 | 1845 | Oct. 22. | 73 30.3 | ---- |
| Sarnia, C. W., garden near the ferry. | 42 58 | 82 22 | 1845 | Oct. 25, 27. | 74 15.7 | ---- |
| Niagara Falls, near Clifton House. | 43 04 | 79 05 | 1841 | Sept. | 74 54.7 | ---- |
| Do. | 43 04 | 79 05 | 1845 | Oct. 18. | 74 46.8 | ---- |
| Cape Ippewash, Lake Huron. | 43 13 | 82 00 | 1860 | May 8. | 74 46 | 3.633 |
| Niagara Village, C. W., garden of Royal Engineer's quarters. | 43 15 | 79 08 | 1843 | Mar. 11. | 74 45.6 | ---- |
| Hamilton, C. W., in yard of Farmers' Inn. | 43 16 | 79 50 | { 1842<br>1845 | Dec. 29.<br>Oct. 31. | 74 56.7<br>74 54.1 } | ---- |
| Toronto, Magnetic Observatory. | 43 39.4 | 79 23.3 | 1841 | 12 months. | 75 16.6 | ---- |
| Do. | 43 39.4 | 79 23.3 | 1842 | Oct. 26. | 75 14.7 | 3.535 |
| Do. | 43 39.4 | 79 23.3 | 1842 | 12 months. | 75 16.4 | ---- |
| Do. | 43 39.4 | 79 23.3 | 1843 | Aug. | 75 11.4 | 3.537 |
| Do. | 43 39.4 | 79 23.3 | 1843 | 12 months. | 75 14.7 | ---- |
| Toronto, 1½ miles east of Observatory. | 43 39 | 79 22 | 1844 | June 19. | 75 12.5 | 3.542 |
| Toronto, Magnetic Observatory. | 43 39.4 | 79 23.3 | 1844 | June 20. | 75 13.4 | 3.540 |
| Do. | 43 39.4 | 79 23.3 | 1844 | 12 months. | 75 14.8 | ---- |
| Do. | 43 39.4 | 79 23.3 | 1845 | Do. | 75 15.5 | 3.5476 |
| Do. | 43 39.4 | 79 23.3 | 1846 | Do. | 75 15.1 | 3.5419 |
| Do. | 43 39.4 | 79 23.3 | 1847 | Do. | 75 15.3 | 3.5381 |
| Do. | 43 39.4 | 79 23.3 | 1848 | Do. | 75 18.3 | 3.5339 |
| Do. | 43 39.4 | 79 23.3 | 1849 | Do. | 75 18.8 | 3.5368 |
| Do. | 43 39.4 | 79 23.3 | 1850 | Do. | 75 20.0 | 3.5322 |
| Do. | 43 39.4 | 79 23.3 | 1851 | Do. | 75 20.4 | 3.5299 |
| Do. | 43 39.4 | 79 23.3 | 1852 | Do. | 75 20.5 | 3.5154 |
| Do. | 43 39.4 | 79 23.3 | 1853 | Do. | 75 22.2 | ---- |
| Do. | 43 39.4 | 79 23.3 | 1854 | Do. | 75 23.0 | ---- |
| Do. | 43 39.4 | 79 23.3 | 1855 | H and F, Sept. to Dec. | 75 23.5 | 3.5154 |
| Do. | 43 39.4 | 79 23.3 | 1856 | 12 months. | 75 24.1 | 3.5049 |
| Do. | 43 39.4 | 79 23.3 | 1857 | Do. | 75 24.3 | 3.4883 |
| Do. | 43 39.4 | 79 23.3 | 1858 | Do. | 75 24.4 | 3.4900 |
| Do. | 43 39.4 | 79 23.3 | 1859 | June 25 and 30. | 75 24 | 3.480 |
| Do. | 43 39.4 | 79 23.3 | 1859 | 12 months. | 75 25.0 | 3.4811 |

*intensities in the United States and adjacent regions.—Continued.*

DOMINION OF CANADA.—Continued.

[Between longitudes 75° and 90° west.]

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| 13.760 | 72.81 | 3.970 | 13.43 | J. H. Lefroy. | Diary Mag. Sur., Canada, Genl. Sir J. H. Lefroy, London, 1883. |
| 13.812 | 73.57 | 3.808 | 13.46 | Do. | Do. |
| ---- | 74.15 | 3.650 | 13.36 | J. N. Nicollet. | Am. Phil. Soc., Vol. VIII, 1843. |
| 13.757 | | | | J. H. Lefroy. | Diary Mag. Sur., Canada, Genl. Sir J. H. Lefroy, London, 1883. |
| 13.940 | 73.97 | 3.717 | 13.46 | W. P. Smith. | U. S. Lake Sur. Rpt., 1882, Genl. C. B. Comstock. |
| 13.852 | 74.07 | 3.695 | 13.46 | J. H. Lefroy. | Diary Mag. Sur., Canada, Genl. Sir J. H. Lefroy, London, 1883. |
| 13.824 | 74.23 | 3.655 | 13.45 | J., and J. H. Lefroy. | Do. |
| ---- | | | | C. J. B. Riddell and C. Younghusband. | Abstracts & results Magl. & Metl. Obsns. at Mag. Obsy., Toronto, Can., from 1841 to 1871, incl., G. T. Kingston, Director, Toronto, 1875. |
| 13.896 | | | | J. H. Lefroy. | Diary Mag. Sur., Canada, Genl. Sir J. H. Lefroy, London, 1883. θ, H & F obs'd. |
| ---- | | | | C. Younghusband. | Abstracts & results Magl. & Metl. Obsns. at Mag. Obsy., Toronto, Can., from 1841 to 1871, incl., G. T. Kingston, Director, Toronto, 1875. |
| ---- | | | | A. D. Bache. | C. S. Rpt., 1862, App. 19. |
| ---- | | | | C. Younghusband. | Abstracts & results Magl. & Metl. Obsns. at Mag. Obsy., Toronto, Can., from 1841 to 1871, incl., G. T. Kingston, Director, Toronto, 1875. |
| 13.88 | | | | J. Locke. | Am. Phil. Soc., 1846, Art. XI, Dr. J. Locke's paper of 1844. |
| 13.90 | | | | Do. | Do. |
| ---- | | | | C. Younghusband and J. H. Lefroy. | Abstracts & results Magl. & Metl. Obsns. at Mag. Obsy, Toronto, Can., from 1841 to 1871, incl., G. T. Kingston, Director, Toronto, 1875. |
| 13.942 | | | | J. H. Lefroy. | Do. |
| 13.914 | | | | Do. | Do. |
| 13.901 | | | | Do. | Do. |
| 13.931 | | | | Do. | Do. |
| 13.952 | | | | Do. | Do. |
| 13.950 | | | | Do. | Do. |
| 13.948 | | | | Do. | Do. |
| 13.892 | | | | Do. | Do. |
| ---- | | | | J. H. Lefroy and G. T. Kingston. | Do. |
| ---- | | | | G. T. Kingston. | Do. |
| 13.940 | | | | Do. | Do. |
| 13.905 | | | | Do. | Do. |
| 13.844 | | | | Do. | Do. |
| 13.852 | | | | Do. | Do. |
| 13.800 | | | | W. P. Smith. | U. S. Lake Sur., Capt. G. G. Meade, Detroit, 1859. |
| 13.825 | | | | G. T. Kingston. | Abstracts & results Magl. & Metl. Obsns. at Mag. Obsy., Toronto, Can., from 1841 to 1871, incl., G. T. Kingston, Director, Toronto, 1875. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

DOMINION OF CANADA—Continued.

[Between longitudes 75° and 90° west.]

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Toronto, Magnetic Observatory. | 43 39.4 | 79 23.3 | 1860 | 12 months. | 75 24.6 | 3.4792 |
| Do. | 43 39.4 | 79 23.3 | 1861 | Do. | 75 23.8 | 3.4839 |
| Do. | 43 39.4 | 79 23.3 | 1862 | 12 months. | 75 23.2 | 3.4853 |
| Do. | 43 39.4 | 79 23.3 | 1863 | Do. | 75 21.5 | 3.4891 |
| Do. | 43 39.4 | 79 23.3 | 1864 | Do. | 75 20.9 | 3.4932 |
| Do. | 43 39.4 | 79 23.3 | 1865 | Do. | 75 21.0 | 3.4925 |
| Do. | 43 39.4 | 79 23.3 | 1866 | Do. | 75 19.2 | 3.4931 |
| Do. | 43 39.4 | 79 23.3 | 1867 | Do. | 75 18.8 | 3.4976 |
| Do. | 43 39.4 | 79 23.3 | 1868 | Do. | 75 20.1 | 3.4980 |
| Do. | 43 39.4 | 79 23.3 | 1869 | Do. | 75 16.7 | 3.4989 |
| Do. | 43 39.4 | 79 23.3 | 1870 | Do. | 75 16.3 | 3.4984 |
| Do. | 43 39.4 | 79 23.3 | 1871 | Do. | 75 16.8 | 3.5003 |
| Do. | 43 39.4 | 79 23.3 | 1885 | April.. | 74 52 | 3.5911 |
| Goodrich, C. W., in garden foot of hill. | 43 45 | 81 41 | 1845 | Oct. 28. | 75 04.8 | ---- |
| Goodrich, C. W., ¼ mile south of Town Hall. | 43 44 | 81 43 | 1860 | July 19. | 75 02 | 3.575 |
| Coburg, C. W., in yard adjoining Parry's house. | 43 56 | 78 10 | 1843 | Apr. 16. | 75 27.2 | ---- |
| Belleville, C. W., in Dr. Reilly's garden. | 44 09 | 77 25 | 1843 | Apr. 17. | 77 01.0 | ---- |
| Kingston, C. W., Artillery Square, Stewart's Pt. and Common. | 44 13 | 76 28.6 | 1842 | Nov. 11 | 77 18.9 | ---- |
| | | | 1843 | Apr. 18. | 77 18.1 | ---- |
| | | | 1845 | June 10. | 77 14.5 | ---- |
| Kingston, C. W., Stewart's Pt. | 44 12 | 76 29.0 | 1845 | June 11. | ---- | ---- |
| Kingston, C. W., the Common near penitentiary. | 44 13 | 76 30.0 | 1845 | June 11. | ---- | ---- |
| Barrie, C. W., garden of Bingham's Hotel. | 44 21 | 79 41 | 1843 | Jan. 24. | 75 49.9 | ---- |
| Brockville, C. W., Rockford's Hotel. | 44 32 | 75 41 | 1845 | June 13. | 76 18.9 | ---- |
| Prescot, Canada West, 500 yards from river, near fort. | 44 35 | 75 30 | 1843 | Apr. 19. | 78 42.5 | ---- |
| Penetanguishene. | 44 47 | 79 58 | 1825 | Apr. 18. | 76 16.0 | ---- |
| Penetanguishene, near Mrs. Wallace's inn. | 44 47 | 79 58 | 1843 | Jan. 26. | 76 04.2 | 3.3224 |
| | | | 1844 | Nov. 11. | 76 20.1 | |
| Williamsburg, Canada West, garden of Broueffle's inn. | 44 55 | 75 07 | 1843 | Apr. 20. | 76 30.8 | ---- |
| Aylmer, left bank. | 45 15 | 75 58 | 1843 | May 5. | 76 41 | ---- |
| Ottawa. | 45 21 | 75 42 | 1856 | Aug. | 76 42 | ---- |
| Chat Falls. | 45 26 | 76 32 | 1843 | May 6. | 75 07 | ---- |
| Fox's Point, right bank. | 45 32 | 75 22 | 1843 | May 4. | 76 35.3 | ---- |
| Grande Calumet portage. | 45 45 | 76 40 | 1843 | May 7. | 76 44.4 | ---- |
| Fort Coulonge. | 45 54.9 | 76 45 | 1843 | May 8. | 77 29.7 | ---- |
| Pointe au Croix, Lake Huron. | 45 55.5 | 81 02 | 1843 | May 16. | 76 31.3 | ---- |
| Ricollet's Fall. | 45 57 | 80 30 | 1843 | May 15. | 76 45.4 | ---- |

*intensities in the United States and adjacent regions.—Continued.*

DOMINION OF CANADA—Continued.

[Between longitudes 75° and 90° west.]

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| 13.811 | | | | G. T. Kingston. | Abstracts & results Magl. & Metl. Obsns. at Mag. Obsy., Toronto, Can., from 1841 to 1871, incl., G. T. Kingston, Director, Toronto, 1875. |
| 13.817 | | | | Do. | Do. |
| 13.814 | 74.88 | 3.589 | 13.759 | Do. | Do. |
| 13.803 | | | | Do. | Do. |
| 13.811 | | | | Do. | Do. |
| 13.810 | | | | Do. | Do. |
| 13.783 | | | | Do. | Do. |
| 13.796 | | | | Do. | Do. |
| 13.817 | | | | Do. | Do. |
| 13.769 | | | | Do. | Do. |
| 13.761 | | | | Do. | Do. |
| 13.776 | | | | Do. | Do. |
| 13.756 | | | | C. Carpmael. | Letter of Director Carpmael of June 8, 1885. |
| 13.833 | | | | J. H. Lefroy. | Diary Mag. Sur., Canada; Sir J. H. Lefroy, London, 1883. |
| 13.841 | 74.31 | 3.641 | 13.46 | | |
| | | | | W. P. Smith. | U. S. Lake Sur. Rpt., 1882; Genl. C. B. Comstock. |
| ---- | 74.46 | ---- | ---- | H. | Diary Mag. Sur. Canada, Sir. J. H. Lefroy, London, 1883. |
| ---- | 76.32 | ---- | ---- | Do. | Do. |
| 14.971 | | | | | |
| 15.060 | | | | J. H. Lefroy and | Do. |
| 15.110 | 76.60 | 3.355 | 14.48 | C. Younghusband. | |
| 14.449 | | | | C. Younghusband. | Do. |
| 15.465 | | | | Do. | Do. |
| ---- | 75.14 | ---- | ---- | J. H. Lefroy. | Do. |
| 13.711 | 75.63 | 3.306 | 13.32 | C. Younghusband. | Do. |
| ---- | 78.02 | ---- | ---- | J. H. Lefroy. | Do. |
| ---- | | | | J. Franklin. | Do. |
| 14.077 | 75.38 | 3.378 | 13.38 | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy. London, 1883. θ, H & F obs'd. |
| 13.964 | 75.82 | 3.311 | 13.52 | Do. | Diary Mag. Sur. Canada, Sir. J. H. Lefroy, London, 1883. |
| 13.836 | 76.00 | 3.241 | 13.40 | Do. | Do. |
| ---- | 75.90 | ---- | ---- | K. Friesach. | K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858. |
| 13.916 | 74.43 | 3.659 | 13.63 | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 13.877 | 75.90 | 3.273 | 13.44 | Do. | Do. |
| 13.832 | 76.05 | 3.227 | 13.39 | Do. | Do. |
| 13.911 | 76.80 | 3.066 | 13.43 | Do. | Do. |
| 13.903 | 75.83 | 3.295 | 13.46 | Do. | Do. |
| 14.130 | 76.07 | 3.291 | 13.67 | Do. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

DOMINION OF CANADA—Continued.

[Between longitude 75° and 90° west.]

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Frazer Bay, Lake Huron. | 46 00 | 81 40 | 1843 | May 17. | 77 05.6 | ---- |
| Pointe Bapteme. | 46 05 | 77 26 | 1843 | May 9. | 77 19.1 | ---- |
| Fort La Cloche. | 46 07 | 82 03 | 1843 | May 18. | 76 50.2 | ---- |
| Snake Island. | 46 10 | 82 40 | 1843 | May 18. | 77 05.5 | ---- |
| Lake Nipessing. | 46 11 | 79 48 | 1843 | May 14. | 77 09.5 | ---- |
| Port des deux Joachims. | 46 12 | 77 40 | 1843 | May 10. | 77 03.8 | ---- |
| Trou Portage. | 46 15 | 78 16 | 1843 | May 11. | 77 24.4 | ---- |
| Little River, first portage. | 46 15.4 | 78 44 | 1843 | May 12. | 77 28.5 | ---- |
| Tessalon Point. | 46 17 | 83 33 | 1843 | May 19. | 76 59.3 | ---- |
| Trout Lake, south side. | 46 18.5 | 79 13 | 1843 | May 13. | 77 21.7 | ---- |
| Pointe aux Pins. | 46 29.9 | 84 29 | 1843 | May 20. | 77 13.4 | ---- |
| Saint Mary, opposite Saulte de Ste. Marie. | 46 30.9 | 84 21.5 | 1844 | Nov. 4. | ---- | 3.0330 |
| Do. | 46 30.9 | 84 21.5 | 1845 | May. | 77 19.5 | ---- |
| Gros Cap. | 46 32 | 84 43 | 1841 | Aug. | 77 05.3 | ---- |
| Pointe au Crepe. | 46 58.0 | 84 44 | 1843 | May 21. | 77 11.5 | ---- |
| Cape Gargantua. | 47 36.9 | 85 05 | 1843 | May 21. | 77 56.1 | 3.1900 |
| Foot of Long Portage. | 47 54.6 | 84 45.0 | 1880 | July 24; Sept. 8. | ---- | 2.818 |
| Michipicoten, Hudson's Bay Post. | 47 56.0 | 84 54 | 1843<br>1844 | May 23.<br>Oct. 30. | 78 07.2 | 2.8701 |
| Michipicoten, fort. | 47 56.0 | 84 54 | 1845 | ---- | 78 05.2 | ---- |
| Michipicoten, Hudson's Bay Company's Grounds. | 47 56.0 | 84 50.6 | 1880 | July 21; Sep. 9. | ---- | 2.860 |
| Otter Island, east side. | 48 07 | 86 07 | 1843 | May 24. | 79 43.6 | ---- |
| Big Stony Portage, upper end. | 48 13.6 | 84 15.3 | 1880 | July 27; Sept. 7. | ---- | 2.750 |
| Tip-Top, near shore. | 48 15 | 86 08 | 1871 | Aug. 26. | 78 56 | 2.708 |
| Sandy Beach, Dog Lake. | 48 17.8 | 84 00.7 | 1880 | July 28. | ---- | 2.784 |
| Thunder Cape. | 48 20 | 88 52 | 1843 | May 28. | 78 23.2 | ---- |
| Fairy Point, Missinaibi Lake. | 48 20.7 | 83 44.0 | 1880 | July 29. | ---- | 2.751 |
| Fort William. | 48 23.5 | 89 13.5 | 1825 | May 11. | 78 20.0 | ---- |
| Do. | 48 23.5 | 89 13.5 | 1843<br>1844 | May 29, 31.<br>Oct. 10, 11. | 78 04.7 | 2.8720 |
| Do. | 48 23.5 | 89 13.5 | 1845 | ---- | 78 11.0 | ---- |
| Portage Ecarté. | 48 25 | 89 44 | 1843 | June 2. | 77 13.5 | ---- |
| Missinaibi, Post of Hudson's Bay Company. | 48 28.6 | 83 28.4 | 1880 | Aug. 2. | ---- | 2.720 |
| Dog Portage. | 48 39 | 89 30 | 1843<br>1844 | June 3.<br>Oct. 9. | 78 26.8 | 2.8361 |
| White River, or Riviere Blanche. | 48 31.6 | 86 14 | 1844 | Oct. 21. | 78 33.1 | 2.8020 |
| The Pic. | 48 35.3 | 86 15 | 1843<br>1844 | May 25.<br>Oct. 17. | 78 36.6 | 2.7262 |
| The Pic, or Fort Pic. | 48 35.3 | 86 15 | 1845 | ---- | 78 34.0 | ---- |

***intensities in the United States and adjacent regions.*— *Continued.***

DOMINION OF CANADA—Continued.

[Between longitudes 75° and 90° west.]

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| 13.906 | 76.40 | 3.160 | 13.44 | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 13.775 | 76.63 | 3.078 | 13.31 | Do. | Do. |
| ---- | 76.15 | ---- | ---- | Do. | Do. |
| 13.850 | 76.40 | 3.148 | 13.39 | Do. | Do. |
| 13.861 | 76.47 | 3.135 | 13.40 | Do. | Do. |
| 13.830 | 76.37 | 3.150 | 13.37 | Do. | Do. |
| 13.914 | 76.72 | 3.088 | 13.44 | Do. | Do. |
| 13.956 | 76.79 | 3.081 | 13.48 | Do. | Do. |
| 14.020 | 76.30 | 3.211 | 13.56 | Do. | Do. |
| 13.949 | 76.67 | 3.106 | 13.47 | Do. | Do. |
| 14.080 | 76.53 | 3.168 | 13.60 | Do. | Do. |
| 13.824 | 76.63 | 3.091 | 13.37 | Do. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ (1845) & H obs'd. |
| ---- | | | | J. Rae. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| --- | 76.40 | ---- | ---- | E. Loomis. | Am. Phil. Soc., Vol. VIII, 1843. |
| 13.959 | 76.50 | 3.149 | 13.49 | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 15.265 | 77.24 | 3.244 | 14.69 | Do. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ & H obs'd. Local disturbance. |
| ---- | ---- | 2.835 | ---- | S. W. Very. | C. & G. S. Rpt., 1881, App. 9. |
| 14.015 | 77.41 | 2.901 | 13.31 | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ, H & F Obs'd. |
| ---- | | | | J. Rae. | Phil. Trans. R. S., 1846, Sir E. Sabine. |
| ---- | | | | S. W. Very. | C. & G. S. Rpt., App. 9. |
| 13.568 | 79.04 | 2.474 | 13.01 | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| ---- | ---- | 2.766 | ---- | S. W. Very. | C. & G. S. Rpt., 1881, App. 9. |
| 13.790 | 78.25 | 2.762 | 13.56 | C. B. Comstock | U. S. Lake Sur. Rpt., 1882. |
| ---- | ---- | 2.800 | ---- | S. W. Very. | C. & G. S. Rpt., 1881, App. 9. |
| 14.218 | 77.70 | 2.916 | 13.69 | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| ---- | ---- | 2.767 | ---- | S. W. Very. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 77.40 | 2.928 | 13.42 | J. Franklin. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 14.078 | | | | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ, H & F obs'd. |
| ---- | | | | J. Rae. | Phil. Trans. R. S., 1846, Sir E. Sabine. |
| 14.013 | 76.53 | 3.153 | 13.54 | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1843. |
| ---- | ---- | 2.736 | ---- | S. W. Very. | C. & G. S. Rpt., 1881, App. 9. |
| 14.124 | 77.76 | 2.892 | 13.64 | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ, H & F obs'd. |
| 14.117 | 77.89 | 2.822 | 13.45 | Do. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ & H obs'd. |
| 13.901 | | | | Do. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ, H & F obs'd. |
| ---- | | | | J. Rae. | Phil. Trans. R. S., 1846, Sir E. Sabine. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

DOMINION OF CANADA—Continued.

[Between longitudes 75° and 90° west.]

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Foot of Swampy Grounds Portage. | 48 41.5 | 83 23.6 | 1880 | Sept. 5. | ---- | 2.752 |
| Peninsula Harbor. | 48 44 | 86 28 | 1824 | ---- | 78 34 | ---- |
| Battle Island, Lake Superior. | 48 45 | 87 33 | {1843<br>1844 | May 26.<br>Oct. 14. | }76 24 | 3.2124 |
| Simpson's Island. | 48 49 | 87 45 | 1843 | May 27. | 78 53.6 | ---- |
| St. Paul's Portage, southwest end. | 48 49.5 | 83 23.5 | 1880 | Sept. 3. | ---- | 2.643 |
| Moose River, above small cascade. | 49 07.7 | 83 21.9 | 1880 | Sept. 3. | ---- | 2.589 |
| Twin Portage, head of portage. | 49 12.3 | 83 24.4 | 1880 | Aug. 6. | ---- | 2.638 |
| Albany Rapids, Moose River. | 49 22.0 | 83 29.8 | 1880 | Sept. 2. | ---- | 2.540 |
| Kettle Portage. | 49 47.1 | 83 16.4 | 1880 | Aug. 8. | ---- | 2.474 |
| Storehouse Portage, head of. | 50 04.1 | 83 16.1 | 1880 | Aug. 29. | ---- | 2.470 |
| Near Cedar Island, Moose River. | 50 21.1 | 82 42.2 | 1880 | Aug. 28. | ---- | 2.453 |
| Near Small Falling Brook, Moose River. | 50 36.4 | 82 07.2 | 1880 | Aug. 11, 12. | ---- | 2.312 |
| Ship Sands, near Moose Factory. | 51 08 | 80 44 | 1846 | ---- | 81 02 | ---- |
| Moose Factory, Hudson's Bay. | 51 15 | 80 56 | 1846 | ---- | 81 30 | ---- |
| Do. | 51 15.4 | 80 40.5 | 1880 | Aug. 15, 20. | ---- | 2.110 |
| Fort Albany, Hudson's Bay. | 51 22 | 82 38 | 1775 | ---- | 79 20 | ---- |

BRITISH POSSESSIONS, NORTHWEST AMERICA.

[South of latitude 51° and west of longitude 90° west.]

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Second Portage. | 48 14.2 | 92 25 | 1843 | June 11. | 77 40.1 | ---- |
| Lake à la Crosse, east end. | 48 24 | 92 04 | 1843 | June 10. | 77 51.0 | ---- |
| Victoria, Vancouver Island. | 48 26 | 123 25 | 1858 | ---- | 71 39 | ---- |
| Esquimalt, Vancouver Island. | 48 26 | 123 27 | 1859 | Jan. 24; Mar. 22. | 71 34.1 | 4.1192 |
| Laurel Point, Victoria, Vancouver Island. | 48 25.4 | 123 22.5 | 1862 | ---- | 71 39 | ---- |
| Esquimalt, Vancouver Island. | 48 26 | 123 27 | 1862 | ---- | 71 52 | ---- |
| Victoria, Vancouver Island. | 48 25.8 | 123 22.2 | 1880 | May 4. | 71 22.1 | 4.106 |
| Esquimalt, Vancouver Island. | 48 25.4 | 123 26.3 | 1881 | Sept. 29, 30; Oct. 1. | 71 30.3 | 4.080 |
| Sturgeon Lake. | 48 27.5 | 92 38 | 1843 | June 12. | 77 44.8 | ---- |
| Rainy Lake. | 48 33.4 | 92 50 | 1843 | June 13. | 77 47.9 | ---- |
| French Portage. | 48 35 | 91 08.4 | 1843 | June 8. | 78 20.4 | ---- |
| Portage of the Two Rivers. | 48 35 | 91 23 | 1843 | June 9. | 77 49.4 | ---- |
| Fort Frances, Hudson's Bay house. | 48 36.6 | 93 26.7 | 1825 | May 27. | 77 18.1 | ---- |
| Do. | 48 36.6 | 93 26.7 | {1843<br>1844 | June 14.<br>Sept. 29. | }77 30 | 3.0404 |
| Do. | 48 36.6 | 93 26.7 | 1845 | ---- | 77 32 | ---- |
| Rainy River, north side. | 48 41 | 94 31 | 1843 | June 16. | 77 57.4 | ---- |
| Savannah. | 48 53 | 90 03.2 | 1825 | May 20. | 78 39.1 | ---- |
| Savannah Portage. | 48 53 | 90 03.2 | 1843 | June 6. | 78 21.8 | ---- |
| Prairie Portage. | 48 57.5 | 90 01.5 | {1843<br>1844 | June 5.<br>Oct. 7. | }78 26.1 | 2.8342 |

***intensities in the United States and adjacent regions.—Continued.***

DOMINION OF CANADA—Continued.

[Between longitudes 75° and 90° west.]

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| ---- | ---- | 2.768 | ---- | S. W. Very. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 77.51 | ---- | ---- | Bayfield. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| 13.659 | 75.71 | 3.268 | 13.24 | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ & H obs'd. Local disturbance. |
| 14.020 | 78.21 | 2.755 | 13.48 | Do. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| ---- | ---- | 2.659 | ---- | S. W. Very. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | ---- | 2.605 | ---- | Do. | Do. |
| ---- | ---- | 2.654 | ---- | Do. | Do. |
| ---- | ---- | 2.556 | ---- | Do. | Do. |
| ---- | ---- | 2.490 | ---- | Do. | Do. |
| ---- | ---- | 2.486 | ---- | Do. | Do. |
| ---- | ---- | 2.469 | ---- | Do. | Do. |
| ---- | ---- | 2.328 | ---- | Do. | Do. |
| 14.07 | 80.34 | 2.258 | 13.46 | T. E. L. Moore. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 14.12 | 80.81 | 2.152 | 13.48 | Do. | Do. |
| ---- | ---- | 2.126 | ---- | S. W. Very. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | ---- | ---- | ---- | Hutchins. | Hansteen's Erdmagnetismus, Christiania, 1819. |

BRITISH POSSESSIONS, NORTHWEST AMERICA.

[South of latitude 51° and west of longitude 90° west.]

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| 14.026 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883. |
| 14.063 | ---- | ---- | ---- | Do. | Do. |
| ---- | | | | K. Friesach. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| 13.103 | | | | R. W. Haig. | B. S. Phil. Trans. R. S., 1864. θ, H and F obs'd. |
| ---- | | | | Richards. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| ---- | 71.4 | 4.076 | 12.78 | Do. | Do. |
| 12.85 | | | | W. H. Dall and M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| 12.87 | | | | H. E. Nichols. | C & G. S. Rpt., 1881, App. 9. θ, H & F obs'd. |
| 14.077 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883. |
| 14.095 | ---- | ---- | ---- | Do. | Do. |
| 14.069 | ---- | ---- | ---- | Do. | Do. |
| 14.031 | ---- | ---- | ---- | Do. | Do. |
| ---- | | | | J. Franklin. | Do. |
| 14.023 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883. θ, H and F obs'd. |
| ---- | | | | J. Rae. | Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883. |
| 14.309 | ---- | ---- | ---- | J. H. Lefroy. | Do. |
| ---- | | | | J. Franklin. | Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883. Dip 98° supposed a misprint for 78°. |
| 14.107 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883. |
| 14.086 | | | | Do. | Diary Mag. Sur. Canada, Genl. Sir J. H. Lefroy, London, 1883. θ, H and F obs'd. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

BRITISH POSSESSIONS, NORTHWEST AMERICA—Continued.

[South of latitude 51° and west of longitude 90° west.]

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Ashtnolou station. | 49 00 | 120 00 | 1860 | Aug. 17, 18. | 72 27.0 | 4.0105 |
| Inchwointum station. | 49 00 | 118 28 | 1860 | Nov. 13. | 72 48.8 | ---- |
| Wigwam River station. | 49 00 | 114 45 | 1861 | July 15; Aug. 14. | 73 30.8 | 3.8268 |
| Akamina station. | 49 01 | 114 04 | 1861 | Aug. 2. | 73 42.7 | ---- |
| Camp Semi-ah-moo. | 49 01 | 122 46 | 1857 | Sept. | 72 02 | 4.0905 |
| Station Semi-ah-moo. | 49 00.7 | 122 46.2 | 1857 | Sept. 8, 9; Oct. 7, 8. | 71 57.0 | 4.1032 |
| Sumass Prairie. | 49 01 | 122 12 | 1858 | Oct. 4, 5; Nov. 10. | 72 22.0 | 4.0509 |
| Schweltza Lake station. | 49 02 | 122 00 | 1859 | July 4, 5. | 72 03.9 | ---- |
| Chilukweyuk Lake. | 49 02 | 121 23 | 1859 | Sept. 7. | 73 31.0 | ---- |
| Chilukweyuck camp. | 49 06 | 121 23 | 1859 | ---- | 72 22.2 | 4.023 |
| Camp No. 11. | 49 07 | 115 16 | 1861 | ---- | 73 37.8 | ---- |
| On Ashtnolou River. | 49 10 | 120 00 | 1860 | July. | 72 36.9 | ---- |
| Namaimo, Vancouver Island. | 49 10 | 124 00 | 1862 | ---- | 71 54 | ---- |
| Departure Bay, Vancouver Island. | 49 12.6 | 123 58.5 | 1880 | May 6. | 71 29.2 | ---- |
| Do. | 49 12.6 | 123 57 | 1881 | Oct. 6, 7. | 71 42.2 | 4.066 |
| New Westminster, Frazer River. | 49 13 | 122 53 | 1862 | ---- | 72 15 | ---- |
| Hecate Bay, Vancouver Island. | 49 15 | 125 56 | 1861 | ---- | 72 37 | ---- |
| Burrard Inlet. | 49 16 | 123 10 | 1859 | ---- | 72 14 | ---- |
| Lake of the Woods (probably), Falcon Island. | 49 19 | 94 40 | 1843 | June 17. | 78 03.7 | ---- |
| Lake of the Woods. | 49 25 | 94 37 | 1843 | June 18. | 78 16.7 | ---- |
| Joseph's Prairie, Camp No. 14. | 49 31 | 115 35 | 1861 | ---- | 73 50.4 | 3.758 |
| Nootka Sound, Vancouver Island, Resolution Cove. | 49 36 | 126 37 | 1778 | April. | 72 29 | ---- |
| Nootka. | 49 36 | 126 37 | 1791 | Aug. 16, 17. | 70 20.7 | ---- |
| Nootka Sound, Vancouver Island. | 49 36 | 126 37 | 1792 | Oct. | 73 56 | ---- |
| Nootka Sound, Friendly Cove. | 49 35.5 | 126 37.5 | 1881 | Sept. 26, 27. | 71 33.0 | 4.083 |
| Henry Bay, Vancouver Island. | 49 36 | 124 51 | 1860 | ---- | 72 25 | ---- |
| Station S, the gap in Cypress Hills. | 49 37.8 | 109 51.4 | 1880 | July 31. | 75 20.4 | ---- |
| Station V, at Willow Creek, near McLeod. | 49 45.3 | 113 24.0 | 1880 | Aug. 17, 18. | 74 46.3 | ---- |
| Rat Portage. | 49 45.9 | 94 33.3 | { 1843<br>1844 | June 20.<br>Sept. 5. | } 78 07.5 | 2.8734 |
| Fort Garry (upper fort). | 49 53.2 | 97 15.6 | 1843 | June 30, 31; July 3. | 78 18.8 | 2.8491 |
| Winnipeg, C. P. R. station (Fort Garry ?). | 49 53(?) | 97 16(?) | 1882 | May 24. | 79 50.4 | ---- |
| Station R, at Maple Creek. | 50 02.6 | 108 51.4 | 1880 | July 24. | 75 50.1 | ---- |
| Winnipeg River, left bank. | 50 10.2 | 95 12 | 1843 | June 21. | 79 10.6 | ---- |
| Slave Falls, portage. | 50 14.7 | 95 40 | 1843 | June 23. | 78 57.1 | ---- |
| Red River, 6 miles from mouth. | 50 18.2 | 96 52 | 1843 | July 4. | 78 34 | ---- |
| Station W, on road from McLeod to Catgaro. | 50 22.4 | 113 48.8 | 1880 | Aug. 20. | 74 44.1 | ---- |
| Station P, north end Old Woman's Lake. | 50 28.9 | 106 46.8 | 1880 | July 20. | 76 51.2 | ---- |

***intensities in the United States and adjacent regions.—Continued.***

BRITISH POSSESSIONS, NORTHWEST AMERICA—Continued.

[South of latitude 51° and west of longitude 90° west.]

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| 13.321 | 72.2 | ---- | ---- | R. W. Haig. | B. S. Phil. Trans. R. S., 1864. θ, H and F obs'd. |
| 13.272 | 72.6 | ---- | ---- | Do. | B. S. Phil. Trans. R. S., 1864. |
| 13.497 | 73.2 | ---- | ---- | Do. | B. S. Phil. Trans. R. S., 1864. θ, H and F obs'd. |
| 13.587 | 73.4 | ---- | ---- | Do. | B. S. Phil. Trans. R. S., 1864. |
| ---- | 71.8 | ---- | ---- | J. S. Harris. | U. S. N. W. Bound. Com.; MS. in C. & G. S. Office. |
| ---- | | | | Do. | Do. |
| 13.366 | 72.1 | ---- | ---- | R. W. Haig. | B. S. Phil. Trans. R. S., 1864, Capt. R. W. Haig, R. A. θ, H and F obs'd. |
| 13.285 | 71.8 | ---- | ---- | Do. | B. S. Phil. Trans. R. S., 1864. |
| 13.180 | 72.2 | ---- | ---- | Do. | Do. |
| ---- | | | | J. S. Harris. | U. S. N. W. Bound. Com.; MS. in C. & G. S. Office. |
| ---- | 73.4 | ---- | ---- | Do. | Do. |
| 13.226 | 72.4 | ---- | ---- | R. W. Haig. | B. S. Phil. Trans. R. S., 1864. |
| ---- | | | | Richards. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| ---- | 71.5 | 4.062 | 12.80 | W. H. Dall and M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| 12.95 | | | | H. E. Nichols. | Do. |
| ---- | 72.0 | ---- | ---- | Richards. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| ---- | 72.4 | ---- | ---- | Do. | Do. |
| ---- | 72.0 | ---- | ---- | Do. | Do. |
| 14.110 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Gen. Sir J. H. Lefroy, London, 1883. |
| 14.044 | ---- | ---- | ---- | Do. | Do. |
| ---- | 73.6 | 3.76 | 13.32 | J. S. Harris. | U. S. N. W. Bound. Com.; MS. in C. & G. S. Office. |
| ---- | | | | J. Cook. | Encyc. Met. London, 1848; Hansteen's Erdmagnetismus, Christiania, 1819. |
| ---- | 71.5 | 4.08 | 12.86 | Don A. Malaspina. | Bode's Astr. Jahrb., Berlin, 1828. |
| ---- | | | | G. Vancouver. | A Voyage of Discovery, by Capt. G. Vancouver, 3 vols., London, 1798. |
| 12.90 | | | | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 72.2 | ---- | ---- | Richards. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| ---- | 75.3 | ---- | ---- | W. H. King. | Geol. Sur. Canada; MS. commun'd by G. M. Dawson. |
| ---- | 74.7 | ---- | ---- | Do. | Do. |
| 14.023 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ, H and F obs'd. |
| 14.050 | 79.8 | ---- | ---- | Do. | Do. |
| ---- | | | | W. Ogilvie. | MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885. |
| ---- | 75.8 | ---- | ---- | W. H. King. | Geol. Sur. Canada; MS. commun'd by G. M. Dawson. |
| 14.204 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 14.094 | ---- | ---- | ---- | Do. | Do. |
| 14.094 | ---- | ---- | ---- | Do. | Do. |
| ---- | 74.7 | ---- | ---- | W. H. King. | Geol. Sur. Canada, MS. commun'd by G. M. Dawson. |
| ---- | 76.8 | ---- | ---- | Do. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

BRITISH POSSESSIONS, NORTHWEST AMERICA—Continued.

[South of latitude 51° and west of longitude 90° west.]

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| North Harbor, Quatsino Sound, Brit. Col. | 50 29.4 | 128 03.6 | 1881 | Sept. 22, 24, 25. | 71 41.3 | 4.050 |
| Port Neville. | 50 31 | 126 04 | 1860 | ---- | 72 19 | ---- |
| Lake Winnipeg. | 50 33.4 | 96 36 | 1843 | June 27. | 79 05.1 | ---- |
| Do. | 50 35 | 96 35.6 | 1843 | June 26. | 78 34.4 | ---- |
| Fort Alexander. | 50 36.9 | 96 22 | 1825 | June 6. | 78 47.1 | ---- |
| Do. | 50 36.9 | 96 22 | 1834 | ---- | 78 54 | ---- |
| Do. | 50 36.9 | 96 22 | {1843<br>1844 | June 25.<br>Sept. 19. | } 78 58.4 | 2.6984 |
| Thompson's River. | 50 41 | 120 11 | 1833 | April. | 73 43 | 3.611 |
| Station A, on Ellice & Touchwood Trail. | 50 42.5 | 101 59.9 | 1880 | May 22–31. | 77 51.5 | ---- |
| Beaver Harbor. | 50 43 | 127 25 | 1860 | ---- | 72 37 | ---- |
| Station K, near Fort on Appelle. | 50 46.3 | 103 48.0 | 1880 | July 5. | 77 23.2 | ---- |
| Anchorage Cove, Kingcome Inlet, Brit. Col. | 50 52.8 | 126 11.7 | 1881 | Aug. 3. | 72 46.1 | 3.808 |
| Waddington Harbor, Brit. Col. | 50 54.0 | 124 49.5 | 1881 | July 30. | 71 58.6 | 4.005 |

BRITISH POSSESSIONS, NORTHWEST AMERICA.

[North of latitude 51° and west of longitude 90° west.]

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| Land Survey station. | 51 00.6 | 111 40.5 | 1882 | Aug. 6. | 76 13.2 | ---- |
| Station X, on north bank of Bow River. | 51 01.9 | 114 00.0 | 1880 | Sept. 10. | 75 23.4 | ---- |
| Lake Winnipeg. | 51 03.6 | 96 56 | 1843 | July 5. | 79 11.8 | ---- |
| Do. | 51 04 | 96 26 | 1844 | Sept. 18. | 79 31.5 | 2.6398 |
| Station O, near Elbow of S. branch. | 51 04.8 | 106 37.0 | 1880 | July 17. | 77 03.9 | ---- |
| Land Survey station. | 51 05 | 110 15 | 1882 | July 15. | 76 14.1 | ---- |
| Station Y, Morleyville. | 51 10.5 | 114 48.5 | 1880 | Sept. 15. | 75 17.0 | ---- |
| Station J, on Appelle trail. | 51 12.5 | 103 53.8 | 1880 | June 30; July 1. | 77 51.6 | ---- |
| Station I, near H. B. House. | 51 21.6 | 104 00.0 | 1880 | June 28. | 77 53.2 | ---- |
| Station H, on Pelly's trail. | 51 32.0 | 103 42.6 | 1880 | June 27, 28. | 78 12.0 | ---- |
| Lake Winnipeg. | 51 34 | 96 43 | 1844 | Sept. 17. | 79 06.1 | 2.7211 |
| Do. | 51 36.7 | 96 53 | 1843 | July 6. | 79 38.0 | ---- |
| Station G. | 51 38.7 | 103 08.0 | 1880 | June 21, 25. | 78 21.2 | ---- |
| Lake Winnipeg, opposite Tete du Chien. | 51 44.5 | 97 02 | 1844 | Sept. 16. | 79 39 | 2.7634 |
| Station D, on right bank of Assiniboine. | 51 44.8 | 102 00.8 | 1880 | June 16, 17. | 78 34.7 | ---- |
| Lake Winnipeg, island east of Bear Island. | 51 46 | 97 00 | 1843 | July 7. | 79 28.3 | ---- |
| Station C, at Swan River barracks. | 51 54.4 | 101 57.3 | 1880 | June 12. | 78 34.5 | ---- |

*intensities in the United States and adjacent regions.—Continued.*

BRITISH POSSESSIONS, NORTHWEST AMERICA—Continued.

[South of latitude 51° and west of longitude 90° west.]

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| 12.89 | 71.7 | 4.05 | 12.90 | H. E. Nichols. | C. & G. S. Rept., 1881, App. 9. |
| ---- | 72.0 | ---- | ---- | Richards. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| ---- | | | | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 14.128 | ---- | ---- | ---- | J. H. Lefroy. | Do. |
| ---- | ---- | ---- | ---- | J. Franklin. | Do. |
| ---- | | | | Back. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| 14.098 | | | | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ, H & F obs'd. |
| 12.88 | ---- | ---- | ---- | D. Douglas. | Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1872. |
| ---- | 77.8 | ---- | ---- | W. H. King. | Geol. Sur. Canada; MS. commun'd by G. M. Dawson. |
| ---- | 72.3 | ---- | ---- | Richards. | Phil. Trans. R. S., 1872. |
| ---- | 77.3 | ---- | ---- | W. H. King. | Geol. Sur. Canada; MS. commun'd by G. M. Dawson. |
| 12.86 | 72.73 | 3.804 | 12.81 | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| 12.94 | 71.94 | 4.001 | 12.91 | Do. | Do. |

BRITISH POSSESSIONS, NORTHWEST AMERICA.

[North of latitude 51° and west of longitude 90° west.]

| | | | | | |
|---|---|---|---|---|---|
| ---- | 76.2 | ---- | ---- | W. Ogilvie. | MS. commun'd by the Hon. E. Deville & M. H. Dall, Feb. 21, 1885. |
| ---- | 75.4 | ---- | ---- | W. H. King. | Geol. Sur. Canada; MS. commun'd by G. M. Dawson. |
| 14.090 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 14.516 | ---- | ---- | ---- | Do. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ & H obs'd. |
| ---- | 77.0 | ---- | ---- | W. H. King. | Geol. Sur. Canada; MS. commun'd by G. M. Dawson. |
| ---- | 76.2 | ---- | ---- | W. Ogilvie. | MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885. |
| ---- | 75.3 | ---- | ---- | W. H. King. | Geol. Sur. Canada; MS. commun'd by G. M. Dawson. |
| ---- | 77.8 | ---- | ---- | Do. | Do. |
| ---- | 77.9 | ---- | ---- | Do. | Do. |
| ---- | 78.2 | ---- | ---- | Do. | Do. |
| 14.393 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ & H obs'd. |
| 14.462 | | | | Do. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| ---- | 78.3 | ---- | ---- | W. H. King. | Geol. Sur. Canada; MS. commun'd by G. M. Dawson. |
| 15.382 | ---- | ---- | ---- | J. H. Lefroy. | Geol. Sur. Canada; MS. commun'd by G. M. Dawson. θ & H obs'd. |
| ---- | 78.6 | ---- | ---- | W. H. King. | Geol. Sur. Canada; MS. commun'd by G. M. Dawson. |
| 14.414 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| ---- | 78.6 | ---- | ---- | W. H. King. | Geol. Sur. Canada; MS. commun'd by G. M. Dawson. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

BRITISH POSSESSIONS, NORTHWEST AMERICA.—Continued.

[North of latitude 51° and west of longitude 90° west.]

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Port McLaughlin, British Columbia. | 52 08.4 | 128 10.3 | 1881 | Aug. 5, 6, 7. | 73 12.1 | 3.785 |
| Rose Harbor, Queen Charlotte Island, British Columbia. | 52 09.1 | 131 15.0 | 1881 | Sept. 19, 20. | 72 30.2 | 3.885 |
| Lake Winnipeg, near Berens River. | 52 20.9 | 97 10 | 1844 | Sept. 14. | 80 24.4 | 2.4010 |
| Do. | 52 22.6 | 97 12 | 1843 | July 8. | 80 39.2 | ---- |
| Do. | 52 31.6 | 97 18 | 1843 | July 10. | 80 05.5 | --- |
| Fort Alexandria. | 52 33 | 122 29 | 1833 | May. | 74 50 | 3.386 |
| Station e, Battleford, near telegraph office. | 52 43 | 108 17 | 1880 | Nov. 2. | 77 49.4 | ---- |
| Carlton House. | 52 50.8 | 106 32 | 1844 | Aug. 26. | 78 30.7 | 2.7438 |
| Station a, at crossing of Pipestone Creek. | 53 04.3 | 113 35.5 | 1880 | Sept. 25. | 77 00.2 | ---- |
| Fort Edmonton. | 53 31.9 | 113 30.3 | 1844 | Aug. 16, 17. | 77 54.2 | 2.9440 |
| Station b, in valley near Edmonton. | 53 32.0 | 113 30 | 1880 | Oct. 6. | 77 30.5 | ---- |
| Fort Pitt. | 53 34.1 | 109 47.2 | 1844 | Aug. 22. | 78 41.0 | 2.7777 |
| Station d, on fourteenth base-line, at crossing, Battleford. | 53 35.9 | 111 24.0 | 1880 | Oct. 17. | 77 56.8 | ---- |
| Norway House, old site. | 53 41.6 | 98 01.4 | 1819 | Oct. 7. | 83 40 | ---- |
| Do. | 53 41.6 | 98 01.4 | 1843 | Aug. 12. | 80 45.4 | ---- |
| Cumberland House. | 53 56.7 | 102 19.2 | 1819 | Dec. 1. | 83 12 (?) | ---- |
| Do. | 53 56.7 | 102 19.2 | 1820 | June 11. | 84 34 (?) | ---- |
| Do. | 53 56.7 | 102 19.2 | 1825 | June 28. | 80 21.1 | ---- |
| Do. | 53 56.7 | 102 19.2 | {1843, 1844} | Aug. | 80 25.0 | {2.3411, 2.3724} |
| Do. | 53 56.7 | 102 19.2 | 1884 | June 17. | 80 23.3 | ---- |
| Norway House, new position. | 53 59.6 | 98 03.9 | {1843, 1844} | July., Aug., Sept. | 81 10.0 | 2.1750 |
| Do. | 53 59.6 | 98 03.9 | 1884 | July 23; Oct. 4. | 81 12.8 | ---- |
| Frazer's Lake. | 54 03 | 124 40 | 1833 | June. | 75 48 | 3.219 |
| Land Survey Station. | 54 21.3 | 114 00 | 1883 | Jan. 1. | 77 58.1 | ---- |
| Fort Assiniboine. | 54 21.7 | 114 28.6 | 1844 | Aug. 11. | 78 15.2 | ---- |
| Stuart's Lake. | 54 27 | 124 20 | 1833 | June. | 76 09 | 3.161 |
| Port Simpson, British Columbia. | 54 33.5 | 130 23.8 | 1862 | ---- | 74 53 | ---- |
| Do. | 54 33.6 | 130 25.5 | 1881 | Aug. 9, 10, 12. | 74 21.0 | 3.503 |
| Oxford House. | 54 56 | 95 30 | 1843 | Aug. 3. | 82 38.8 | ---- |

***intensities in the United States and adjacent regions.—Continued.***

BRITISH POSSESSIONS, NORTHWEST AMERICA—Continued.

[North of latitude 51° and west of longitude 90° west.]

| Total force, F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| 13.10 | 73.2 | 3.785 | 13.10 | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| 12.92 | 72.5 | 3.885 | 12.92 | Do. | Do. |
| 14.396 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ & H obs'd. |
| 14.150 | | | | Do. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 14.125 | | | | Do. | Do. |
| 12.98 | ---- | ---- | ---- | D. Douglas. | Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1872. |
| ---- | 77.8 | ---- | ---- | W. H. King. | Geol. Sur. Canada; MS. commun'd by G. M. Dawson. |
| 13.782 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ & H obs'd. |
| ---- | 77.0 | ---- | ---- | W. H. King. | Geol. Sur. Canada; MS. commun'd by G. M. Dawson. |
| 14.000 | 77.5 | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ, H & F obs'd. |
| ---- | | | | W. H. King. | Geol. Sur. Canada; MS. commun'd by G. M. Dawson. |
| 14.154 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ & H obs'd. |
| ---- | 77.9 | ---- | ---- | W. H. King. | Geol. Sur. Canada; MS. commun'd by G. M. Dawson. |
| ---- | ---- | ---- | ---- | J. Franklin. | Encyc. Met. London, 1848, Art. Mag.; Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 14.162 | | | | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| ---- | 80.4 | ---- | ---- | J. Franklin. | Encyc. Met. London, 1848, Art. Magnetism. Dip defective by 3½° or 4°. |
| ---- | | | | Do. | Do. |
| ---- | | | | Do. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 14.143 | | | | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ, H & F obs'd. |
| 14.042 | | | | O. J. Klotz. | MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885. |
| 14.098 | 81.2 | 2.151 | 14.06 | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ, H & F obs'd. |
| 14.063 | | | | O. J. Klotz. | MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885. |
| 13.14 | ---- | ---- | ---- | D. Douglas. | Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1872. |
| ---- | 78.0 | ---- | ---- | W. Ogilvie. | MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885. |
| ---- | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 13.21 | ---- | ---- | ---- | D. Douglas. | Rpt. Brit. Asso., Vol. VI, 1838; Phil. Trans. R. S., 1872. |
| ---- | 74.3 | 3.503 | 12.95 | Richards. | Phil. Trans. R. S., 1872. |
| 12.98 | | | | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| 14.192 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

BRITISH POSSESSIONS, NORTHWEST AMERICA—Continued.

[North of latitude 51° and west of longitude 90° west.]

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Land Survey Station. | 55 10 | 114 03.5 | 1883 | May 10. | 78 29.1 | ---- |
| Observatory Inlet. | 55 15.5 | 129 44 | 1793 | ---- | 75 54.5 | ---- |
| Isle à la Crosse. | 55 26.8 | 107 54 | 1825 | July 11. | 79 55.0 | ---- |
| Fort à la Crosse. | 55 26.8 | 107 54 | 1843 | Sept. 9. | 80 09.8 | 2.3889 |
| Land Survey Station. | 55 32.5 | 116 08.6 | 1883 | Oct. 3. | 78 15.1 | ---- |
| Fort Lesser Slave Lake. | 55 32.6 | 116 00 | 1844 | Aug. 5. | 78 39.0 | 2.7298 |
| Fort Dunvegan. | 55 55.6 | 118 28.5 | 1844 | July 22–25. | 78 46.2 | 2.7243 |
| Land Survey Station. | 56 08 | 117 50.6 | 1883 | Sept. 22. | 78 17.2 | ---- |
| York, Factory, Hudson's Bay. | 56 59.9 | 92 26 | 1843 | July 24–26. | 83 47.2 | 1.5052 |
| Do. | 56 59.9 | 92 26 | 1845<br>1846 | Nov. 5.<br>May 16. | 83 42.6 | ---- |
| Do. | 56 59.9 | 92 26 | 1847 | Sept. 18. | 83 47.0 | ---- |
| Do. | 56 59.9 | 92 26 | 1857 | Aug. | 83 53 | ---- |
| Do. | 56 59.9 | 92 26 | 1884 | Sept. 11. | 83 46.9 | ---- |
| Fort Vermilion or Fort Lefroy. | 58 24.5 | 115 58.6 | 1844 | July 12. | 80 48.0 | 2.2482 |
| Fort Chipewyan, Lake Athabasca. | 58 43 | 111 18.7 | 1825 | July 24. | 81 26.1 | ---- |
| Do. | 58 43 | 111 18.7 | 1843<br>1844 | Sept., Oct.<br>Feb., Mar., July. | 81 36.8 | 2.0267 |
| Do. | 58 43 | 111 18.7 | 1883 | Sept. 17. | 81 20.6 | ---- |
| Fort Churchill. | 58 43.8 | 94 14 | 1846 | June 29; July 4. | 84 46.8 | ---- |
| Fort Resolution, Great Slave Lake. | 61 10.7 | 113 46 | 1844 | June 22. | 82 44.4 | 1.7636 |
| Fort Simpson. | 61 51.7 | 121 25.3 | 1825 | Aug. 5. | 81 53.1 | ---- |
| Do. | 61 51.7 | 121 25.3 | 1844 | Mar. 28; May 10. | 81 52.2 | 1.9533 |
| Fort Norman, west side of river, or old site. | 64 40.6 | 124 44.8 | 1844 | May 28; June 2. | 82 34.3 | 1.7652 |
| Fort Good Hope, Mackenzie River. | 66 16 | 128 31 | 1844 | May 29. | 82 55.9 | 1.6918 |
| Fort Confidence. | 66 54 | 118 49 | 1839 | June. | 84 48 | ---- |
| Do. | 66 54 | 118 49 | 1848 | Oct., Nov., Dec. | 84 50.2 | 1.203 |
| Do. | 66 54 | 118 49 | 1849 | Jan., Feb., Mar. | 84 51.0 | 1.208 |
| Richardson's Chain. | 69 01 | 137 25 | 1826 | ---- | 82 22 | ---- |
| Clarence Bay, Arctic Ocean. | 69 38 | 140 51 | 1826 | ---- | 83 27 | ---- |

*intensities in the United States and adjacent regions.—Continued.*

BRITISH POSSESSIONS, NORTHWEST AMERICA—Continued.

[North of latitude 51° and west of longitude 90° west.]

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| 13.734 | 78.5 | 2.740 | 13.73 | W. Ogilvie. | MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885. |
| ---- | ---- | ---- | ---- | G. Vancouver. | Encyc. Met. London, 1848. |
| ---- | ---- | ---- | ---- | J. Franklin. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 14.012 | | | | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ, H & F obs'd. |
| 13.572 | 78.3 | 2.75 | 13.57 | W. Ogilvie. | MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885. |
| 13.872 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883, θ & H obs'd. |
| 14.000 | ---- | ---- | ---- | Do. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ, H & F obs'd. |
| 13.614 | 78.3 | 2.76 | 13.61 | W. Ogilvie. | MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885. |
| 14.051 | | | | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ, H & F obs'd. |
| ---- | | | | J. Rae. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| ---- | 83.8 | 1.504 | 13.93 | Do. | Do. |
| ---- | | | | R. B. Blakiston. | Do. |
| 13.926 | | | | O. J. Klotz. | MS. commun'd by the Hon. E. Deville & W. H. Dall, Feb. 21, 1885. |
| 14.022 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ, H & F obs'd. |
| ---- | | | | J. Franklin. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 13.885 | 81.3 | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ, H & F obs'd. |
| ---- | | | | H. P. Dawson. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| ---- | ---- | ---- | ---- | J. Rae. | Do. |
| 13.956 | ---- | ---- | ---- | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ & H obs'd. |
| ---- | ---- | ---- | ---- | J. Franklin. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 13.808 | | | | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. θ & H obs'd. |
| 13.653 | ---- | ---- | ---- | Do. | Do. |
| 13.681 | ---- | ---- | ---- | Do. | Do. |
| ---- | | | | T. Simpson. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| 13.58 | 84.8 | ---- | ---- | J. Richardson. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 13.60 | | | | Do. | Do. |
| ---- | ---- | ---- | ---- | J. Franklin. | Phil. Trans. R. S., 1872, Sir E. Sabine, Cont. XIII. |
| ---- | ---- | ---- | ---- | Do. | Do. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

WEST INDIA ISLANDS AND BERMUDAS.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Trinidad, Port of Spain. | 10 39 | 61 33 | 1822 | ---- | 39 02 | ---- |
| Do. | 10 39 | 61 33 | 1830 | ---- | 39 00 | ---- |
| Santa Marta, Colombia, South America. | 11 15 | 74 15 | 1857 | ---- | 36 34 | ---- |
| Curaçoa. | 12 06 | 68 56 | 1833 | ---- | 38 39 | ---- |
| Barbadoes, Carlisle Bay. | 13 05 | 59 37 | 1835 | May 11. | 43 45.9 | } 6.65 |
| Do. | 13 05 | 59 37 | 1836 | Jan. 5. | 43 28.8 | |
| Barbadoes. | 13 05 | 59 37 | 1846 | ---- | 43 57 | ---- |
| Antigua, fort in English Harbor. | 17 03 | 61 50 | 1835 | Apr. 30. | 48 46.2 | 6.90 |
| Antigua, Caribbee Islands. | 17 08 | 61 52 | 1848 | ---- | 49 11 | ---- |
| Alta Vela, off San Domingo. | 17 28 | 71 39 | 1835 | Feb. 6. | 47 39 | 6.48 |
| Kingston (or Port Royal), Jamaica. | 17 56 | 76 51 | 1822 | ---- | 46 55 | ---- |
| Do. | 17 56 | 76 51 | 1834 | ---- | 47 19 | ---- |
| Kingston, on the point at Port Royal. | 17 56 | 76 51 | 1834 | July 11; Aug. 1; Sept. 30; Oct. 6. | 47 01.3 | 7.08 |
| Kingston. | 17 57 | 76 49 | 1857 | Feb. 25; Mar. 2. | 46 32 | 7.179 |
| Anguilla Island, Caribbee Islands. | 18 14 | 63 05 | 1846 | ---- | 50 15 | ---- |
| St. Thomas. | 18 20 | 64 56 | 1834 | ---- | 49 29 | ---- |
| Do. | 18 20 | 64 56 | 1846 | ---- | 49 40 | ---- |
| Do. | 18 20 | 64 55 | 1857 | Feb. 17. | 48 30 | 6.723 |
| Do. | 18 20 | 64 55 | 1865 | Nov. 14. | 49 38 | 6.758 |
| Porto Rico, San Juan. | 18 29 | 66 10 | 1852 | ---- | 50 15 | ---- |
| Cayman Island. | 19 14 | 81 05 | 1822 | ---- | 48 48 | ---- |
| Barracoa, Cuba. | 20 22 | 74 29 | 1831 | ---- | 50 07 | ---- |
| Cozumel. | 20 33 | 86 57 | 1879 | Apr 23, 24, 25. | 48 06.5 | 7.176 |
| Mugeres Island. | 21 14.7 | 86 45.7 | 1879 | Apr. 28, 29, 30. | 49 32.9 | 7.063 |
| Cape San Antonio, Cuba. | 21 55.5 | 84 55 | 1879 | Apr. 7, 8, 9. | 50 14.9 | 7.035 |
| Arenas Cay. | 22 07.2 | 91 24.9 | 1880 | Jan. 28, 29. | 49 35.8 | 7.103 |
| Perez Island. | 22 23.5 | 89 42.0 | 1880 | Jan. 22, 23. | 50 09.7 | 7.055 |
| Bahia Honda, Cuba. | 22 58.4 | 83 12 | 1879 | Mar. 28, 29, 31. | 52 18.4 | 6.858 |
| Matanzas, Cuba. | 23 02.9 | 81 36.9 | 1879 | Mar. 6, 7, 8. | 52 23.4 | 6.823 |
| Havana. | 23 09 | 82 23 | 1801 | Jan. | 53.22 | 6.10(?) |
| Do. | 23 09 | 82 22 | 1822 | ---- | 51.55 | ---- |
| Do. | 23 09 | 82 22 | 1857 | Jan. 27, 28. | 52 00 | 6.921 |
| Havana, Jesuit College of Belen. | 23 08.2 | 82 21.3 | 1879 | Mar. 13–16. | 52 18.1 | 6.847 |
| Water Cay, Salt Key Banks. | 23 59.2 | 80 20.8 | 1879 | Feb. 28. | 53 41.6 | 6.742 |
| Nassau, New Providence Island. | 25 05 | 77 22 | 1841 | ---- | 56 13 | ---- |
| Do. | 25 05 | 77 22 | 1843 | ---- | 56 23 | ---- |
| Nassau, New Providence, on Hog Island. | 25 05.5 | 77 20.0 | 1879 | Feb. 18, 19, 20. | 55 50.5 | 6.503 |
| South Bemini, Bahama Islands. | 25 42 | 79 17.6 | 1879 | Feb. 24, 25, 26. | 56 20.3 | 6.448 |
| Bermuda, signal station, St. George's Town. | 32 23 | 64 42 | 1831 | ---- | 65 18 | ---- |
| Do. | 32 23 | 64 42 | 1845 | Oct. | 65 26.2 | ---- |
| Do. | 32 23 | 64 42 | 1846 | ---- | 65 24 | ---- |

*intensities in the United States and adjacent regions.—Continued.*

WEST INDIA ISLANDS AND BERMUDAS.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| 8.98 | ---- | ---- | ---- | E. Sabine. | Phil. Trans. R. S., 1875. |
| ---- | | | | Foster. | Do. |
| 9.52 | ---- | ---- | ---- | K. Friesach. | Do. |
| ---- | ---- | ---- | ---- | Zahrtmann. | Do. |
| 9.18 | | | | E. Home. | Phil. Trans. R. S., 1838. |
| | ---- | ---- | ---- | Do. | Do. |
| ---- | | | | Schomburgh. | Phil. Trans. R. S., 1875. |
| 10.08 | ---- | ---- | ---- | E. Home. | Phil. Trans. R. S., 1838. |
| ---- | | | | Barnett. | Phil. Trans. R. S., 1875. |
| 9.41 | ---- | ---- | ---- | E. Home. | Phil. Trans. R. S., 1838. |
| ---- | | | | E. Sabine. | Phil. Trans. R. S., 1875, Sir E. Sabine, Cont. XIV. |
| ---- | | | | Barnett. | Do. |
| 10.52 | 47.4 | 7.12 | 10.52 | E. Home. | Phil. Trans. R. S., 1838. |
| 10.436 | | | | K. Friesach. | K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858. |
| ---- | 50.8 | ---- | ---- | Barnett. | Phil. Trans. R. S., 1875. |
| ---- | | | | Zahrtmann. | Phil. Trans. R. S., 1875, Sir E. Sabine, Cont. XIV. |
| ---- | 49.9 | 6.73 | 10.45 | Schomburgh. | Do. |
| 10.139 | | | | K. Friesach. | K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858. |
| 10.434 | | | | W. Harkness. | Smithsonian Cont's to Know., No. 239, Wash., 1873, Cruise of the Monadnock. |
| ---- | 50.7 | ---- | ---- | Norwegian officer. | Phil. Trans. R. S., 1875. |
| --- | ---- | ---- | ---- | E. Sabine. | Do. |
| ---- | ---- | ---- | ---- | Foster. | Do. |
| 10.75 | 48.2 | 7.15 | 10.73 | S. M. Ackley. | C. & G. S. Rpt., 1881, App. 9. |
| 10.89 | 49.6 | 7.03 | 10.85 | Do. | Do. |
| 11.00 | 50.3 | 7.01 | 10.98 | Do. | Do. |
| 10.96 | 49.7 | 7.08 | 10.95 | Do. | Do. |
| 11.01 | 50.2 | 7.03 | 10.98 | Do. | Do. |
| 11.22 | 52.4 | 6.83 | 11.19 | Do. | Do. |
| 11.18 | 52.5 | 6.80 | 11.17 | Do. | Do. |
| 10.23 (?) | | | | A. v. Humboldt. | Becquerel's Traité du Magnétisme, Paris, 1846; Rpt. Brit. Asso., Vol. VI, 1838; C. S. Rpt., 1861, App. 22. |
| 11.30 | 52.4 | 6.82 | 11.18 | E. Sabine. | Rpt. Brit. Asso., Vol. VI, 1838; C. S. Rpt., 1861, App. 22. |
| 11.243 | | | | K. Friesach. | K. K. Acad. d. Wiss., Vienna, Vol. XXIX, 1858. |
| 11.20 | | | | S. M. Ackley. | C. & G. S. Rpt., 1881, App. 9. |
| 11.39 | 53.7 | 6.72 | 11.35 | Do. | Do. |
| ---- | | | | Barnett. | Phil. Trans. R. S., 1875. |
| ---- | 56.0 | 6.50 | 11.62 | Do. | Do. |
| 11.58 | | | | S. M. Ackley. | C. & G. S. Rpt., 1881, App. 9. |
| 11.63 | 56.3 | 6.44 | 11.61 | Do. | Do. |
| ---- | ---- | ---- | ---- | Austin and Foster. | Phil. Trans. R. S., 1875, Sir E. Sabine. |
| ---- | ---- | ---- | ---- | Barnett. | Bermuda Royal Gazette. |
| ---- | ---- | ---- | ---- | Do. | Phil. Trans. R. S., 1875, Sir E. Sabine. |

**TABLE I.**—*Observed magnetic dips and horizontal and total magnetic*

WEST INDIA ISLANDS AND BERMUDAS—Continued.

| Name of station. | Latitude $\varphi$. | West longitude $\lambda$. | Year. | Month. | Dip $\theta$. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Bermuda, Mount Langton. | 32 18.2 | 64 49 | 1872 | Nov. 5–11. | 67 20.1 | ---- |
| Bermuda, Mount Langton, garden. | 32 18.2 | 64 49.5 | 1873 | Apr. 10, 11. | 67 20 | 4.764 |
| Bermuda, Mount Langton, Ducking Stool. | 32 18.2 | 64 49 | 1873 | June 6, 9. | 66 44.7 | 4.789 |
| Bermuda, Tatem Island. | 32 17.2 | 64 53.3 | 1873 | June 5. | 67 02.8 | ---- |
| Bermuda, Somerset Island. | 32 18 | 64 53.5 | 1873 | Apr. 7. | 65 44.2 | 5.073 |
| Bermuda, Spanish Point. | 32 18.2 | 64 50.5 | 1873 | Apr. 12, 17. | 67 19.8 | 4.786 |
| Bermuda, Ireland Island, cemetery spar-yard. | 32 18.7 | 64 52.2 | 1873 | Apr. 9, 12. | {66 27.6<br>66 33.8} | ---- |
| Bermuda, Clarence Cove. | 32 18.8 | 64 50 | 1873 | June 3, 9. | 66 44 | 4.914 |
| Bermuda, in the dock-yard. | 32 19 | 64 51 | 1834 | June 11, 16. | 67 45 | } 4.82 |
| Do. | 32 19 | 64 51 | 1836 | Feb. 6. | 67 18 | |
| Bermuda, near dock-yard. | 32 19.2 | 64 51.8 | 1873 | May 13; June 10, 12. | 66 25.8 | 4.922 |

MEXICO AND CENTRAL AMERICA.

| | | | | | | |
|---|---|---|---|---|---|---|
| Panama. | 8 57 | 79 29 | 1790 | Oct. 3. | 29 29 | ---- |
| Do. | 8 57 | 79 29 | 1837 | ---- | 31 51.9 | 7.743 |
| Do. | 8 57 | 79 31 | 1858 | Apr. 29; May 2. | 32 30 | 7.654 |
| Do. | 8 54 | 79 30 | 1866 | May 14. | 31 56 | 7.614 |
| Chagres, castle of Saint Lorenzo. | 9 20 | 80 01 | 1834 | Sept. 18, 19. | 32 30 | 7.55 |
| Nicaragua, Point Arenas. | 10 58 | 83 43 | 1834 | Sept. 11, 12. | 34 05 | 7.56 |
| Nicaragua, or Rivas. | 10 56 | 83 42 | 1839 | ---- | 34 43 | ---- |
| Realejo, Nicaragua. | 12 36 | 87 18 | 1791 | Jan 25. | 33 05 | ---- |
| Do. | 12 28 | 87 08 | 1838 | ---- | 34 36.9 | ---- |
| La Union, Chiquiriu Point, San Salvador. | 13 17.2 | 87 46.4 | 1880 | Nov. 1, 2. | 38 23.9 | 7.284 |
| Acajutla, San Salvador. | 13 34.1 | 89 50.7 | 1880 | Nov. 6, 7. | 37 49.7 | 7.498 |
| Port Escondido. | 16 04.1 | 96 56.7 | 1880 | Nov. 17, 18. | 39 13.2 | 7.504 |
| Salina Cruz, Tehuantepec. | 16 09.6 | 95 26.7 | 1880 | Nov. 13, 14, 15. | 40 08.5 | 7.479 |
| Acapulco, Mexico. | 16 50 | 99 52 | 1791 | Apr. 29. | 36 07.5 | ---- |
| Do. | 16 50.5 | 99 53 | 1803 | March. | 38 53 | ---- |
| Do. | 16 50 | 99 55 | 1838 | ---- | 37 57.4 | 7.91 |
| Do. | 16 50 | 99 52 | 1866 | May 30. | 39.54 | 7.740 |
| Do. | 16 49.2 | 99 56.3 | 1880 | Nov. 22, 23, 24. | 40 08.5 | 7.518 |
| Belize, British Honduras. | 17 29 | 88 12.3 | 1879 | Apr. 15, 16, 18. | 43 32.3 | 7.425 |
| Coatzacoalcos, Mexico. | 18 08 | 94 26 | 1880 | Feb. 20, 21, 23. | 43 03.3 | 7.398 |
| Clarion Island, off Lower California. | 18 21 | 114 41 | 1839 | ---- | 37 03 | 7.597 |
| Do. | 18 19.6 | 114 41.9 | 1880 | Oct. 8, 9. | 39 34.0 | 7.357 |
| Laguna de Terminos, Gulf of Campeche. | 18 38 | 93 00 | 1880 | Mar. 2, 3, 4. | 44 18.3 | 7.353 |
| Socorro Island, off Lower California. | 18 43 | 110 54 | 1839 | ---- | 40 43.7 | 7.477 |
| Do. | 18 42.8 | 110 54.2 | 1880 | Oct. 11, 12. | 41 18.7 | 7.513 |

***intensities in the United States and adjacent regions.—Continued.***

WEST INDIA ISLANDS AND BERMUDAS—Continued.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| ---- | (67.06) | (4.77) | (12.24) | J. H. Lefroy. | Diary Mag. Sur. Canada, Sir J. H. Lefroy, London, 1883. |
| 12.362 | ---- | ---- | ---- | Maclear and Sloggett. | Voy. of H. M. S. Challenger, Capt. G. S. Nares, Vol. II, London, 1882. |
| 12.129 | ---- | ---- | ---- | Maclear and Bromley. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| 12.345 | ---- | ---- | ---- | Maclear and Sloggett. | Do. |
| 12.417 | ---- | ---- | ---- | Do. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| 12.443 | ---- | ---- | ---- | Maclear and Bromley. | Do. |
| 12.32 | ---- | ---- | ---- | E. Home. | Phil. Trans. R. S., 1838, Pt. I, Capt. Sir E. Home. [Lat. and long. corrected.] |
| | ---- | ---- | ---- | Do. | Do. |
| 12.309 | (66.49) | (4.91) | (12.31) | Maclear and Bromley. | Voy. of H. M. S. Challenger, Capt. G. S. Nares, Vol. II, London, 1882. |

MEXICO AND CENTRAL AMERICA.

| Total force F. | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| ---- | 32.9 | 7.514 | 8.95 | Don A. Malaspina. | Bode's Astr. Jahrb. Berlin, 1828. |
| 9.123 | | | | E. Belcher. | Phil. Trans. R. S., 1843. |
| 9.075 | | | | R. W. Haig. | Phil. Trans. R. S., 1864. |
| 8.972 | | | | W. Harkness. | Smithsonian Cont's to Know., No. 239, Wash., 1873. |
| 9.02 | 34.0 | ---- | ---- | E. Home. | Phil. Trans. R. S., 1838, pt. I. |
| 9.34 | 35.8 | ---- | ---- | Do. | Do. |
| ---- | | | | Barnett. | Phil. Trans. R. S., 1875. |
| ---- | 36.0 | ---- | ---- | Don A. Malaspina. | Bode's Astr. Jahrb., Berlin, 1828. |
| ---- | | | | E. Belcher. | Phil. Trans. R. S., 1843. |
| 9.29 | 38.53 | 7.262 | 9.28 | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| 9.49 | 37.96 | 7.476 | 9.48 | Do. | Do. |
| 9.68 | 39.35 | 7.482 | 9.68 | Do. | Do. |
| 9.78 | 40.27 | 7.457 | 9.77 | Do. | Do. |
| ---- | 40.35 | 7.57 | 9.93 | Don A. Malaspina. | Bode's Astr. Jahrb., Berlin, 1828. |
| ---- | | | | A. v. Humboldt (?) | Becquerel's Traité du Magnétisme, Paris, 1846. |
| 10.03 | | | | E. Belcher. | Phil. Trans. R. S., 1843 & 1875. |
| 10.089 | | | | W. Harkness. | Smithsonian Cont's to Know., No, 239, Wash., 1873. |
| 9.83 | | | | H. E. Nichols. | C. & G.S. Rpt., 1881, App. 9. |
| 10.24 | 43.7 | 7.395 | 10.23 | S. M. Ackley. | Do. |
| 10.12 | 43.2 | 7.373 | 10.11 | Do. | Do. |
| 9.52 | 39.73 | 7.335 | 9.54 | E. Belcher. | Phil. Trans. R. S., 1843 & 1875. |
| 9.54 | | | | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| 10.28 | 44.46 | 7.329 | 10.27 | S. M. Ackley. | Do. |
| 9.87 | 41.47 | 7.491 | 10.00 | E. Belcher. | Phil. Trans. R. S., 1843 & 1875. |
| 10.00 | | | | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

MEXICO AND CENTRAL AMERICA—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Cocolopam, Orizaba. | 18 53 | 97 04 | 1856 | Aug. 26, 27. | 42 51 | 7.579 |
| Potrero. | 18 56 | 96 48 | 1856 | Aug. 16, 17. | 42 51 | 7.574 |
| San Andres, Chalchecomula, State of Puebla. | 18 59 | 97 15 | 1856 | Sept. 17, 18. | 42 38 | 7.589 |
| Manzanilla. | 19 02.8 | 104 20.5 | 1880 | Nov. 30; Dec. 1. | 43 15.8 | 7.320 |
| Tlamacas. | 19 03 | 98 39 | 1857 | Jan. 25. | 42 34 | 7.571 |
| Vera Cruz, Villa la Guaca, south of city. | 19 12 | 96 09 | 1856 | Aug. 7, 8. | 43 58 | 7.533 |
| Vera Cruz, northeast bastion, castle of San Juan d'Ulloa. | 19 12.2 | 96 08.5 | 1880 | Feb. 10, 11, 12. | 44 04.6 | 7.391 |
| Mirador, State of Vera Cruz. | 19 13 | 96 37 | 1856 | Oct. 10, 11. | 43 50 | 7.522 |
| Chalco. | 19 18 | 98 51 | 1857 | Jan. 6. | 43 12 | 7.540 |
| Mexico, city. | 19 26 | 99 06 | 1778 | ---- | 38 00 | ---- |
| Do. | 19 26 | 99 06 | 1799 | ---- | 42 10 | ---- |
| Mexico, Convent of San Augustin. | 19 26 | 99 05 | 1803 | Dec. | 42 10 | 6.69 (?) |
| Do. | 19 26 | 99 05 | 1857 | Dec. 10, 17. | 41 26 | 7.576 |
| Mexico, Central Observatory for Magnetism and Meteorology. | 19 26 | 99 06.6 | 1879 | Sept.–Dec. | 44 51.7 | 7.480 |
| Do. | 19 26 | 99 06.6 | 1884 | Apr. 5, 8, 9, 11, 19. | 45 01.4 | ---- |
| Campeche, Yucatan, | 19 50.5 | 90 33.3 | 1880 | Mar. 8, 9, 10. | 46 20.7 | 7.229 |
| Progresso, Yucatan. | 21 16.8 | 89 39.5 | 1880 | Mar. 13, 15. | 48 52.3 | 7.090 |
| San Blas, Mexico. | 21 32 | 105 16 | 1791 | Apr. 12. | 43 11.2 | ---- |
| Do. | 21 32 | 105 16 | 1837 | ---- | 46 09 | ---- |
| San Blas, Palm Island. | 21 32 | 105 16 | 1837 | ---- | 45 24.3 | ---- |
| San Blas, Mexico. | 21 32 | 105 16 | 1838 | ---- | 44 36 | ---- |
| San Blas, Beach. | 21 32 | 105 16 | 1839 | ---- | 44 32.5 | 7.421 |
| San Blas, Mexico. | 21 32.2 | 105 18.1 | 1880 | Dec. 4, 5. | 46 20.8 | 7.204 |
| Contoy Island. | 21 32 | 86 49 | 1838 | ---- | 49 48 | ---- |
| Arenas. | 22 07 | 91 24 | 1847(?) | ---- | 49 32 | ---- |
| San Lucas Bay. | 22 52 | 109 53 | 1839 | ---- | 45 39.3 | 7.259 |
| Cape San Lucas, Lower California. | 22 53.6 | 109 54.7 | 1881 | Feb. 19, 20. | 47 23.2 | 7.103 |
| San José del Cabo, Lower California. | 23 03.6 | 109 40.7 | 1873 | Feb. 27, 28. | 47 25.2 | 7.007 |
| Mazatlan, Mexico. | 23 11 | 106 24 | 1837 | ---- | 47 45 | ---- |
| Do. | 23 11 | 106 24 | 1839 | ---- | 46 38.5 | 7.214 |
| Do. | 24 11.5 | 106 26.6 | 1881 | Feb. 12, 13. | 48 15.8 | 7.049 |
| La Paz, El Mogote, Lower California. | 24 10.2 | 110 20.7 | 1881 | Feb. 6, 7. | 49 10.1 | 7.023 |
| Pichilingue Bay, Lower California. | 25 15.5 | 110 20.1 | 1881 | Feb. 5. | 49 48.5 | 6.885 |
| Magdalena Bay, Lower California. | 24 38 | 112 07 | 1837 | ---- | 50 43 | ---- |
| Do. | 24 38 | 112 07 | 1839 | ---- | 46 34 | 7.160 |
| Do. | 24 40 | 112 07 | 1866 | June 9. | 48 32 | 7.176 |
| Do. | 24 38.4 | 112 08.9 | 1873 | Mar. 6, 7. | 48 09.0 | 6.926 |
| Do. | 24 38.4 | 112 08.9 | 1881 | Feb. 24. | 48 18.7 | 7.032 |

*intensities in the United States and adjacent regions.—Continued.*

MEXICO AND CENTRAL AMERICA—Continued.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| ---- | 43.5 | 7.43 | 10.24 | A. Sonntag and v. Mueller. | C. S. Rpt., 1856, p. 214 & Smithsonian Cont's to Know., Wash., 1860. |
| ---- | 43.5 | 7.43 | 10.24 | Do. | Do. |
| ---- | 43.3 | 7.44 | 10.22 | Do. | Do. |
| 10.05 | 43.40 | 7.300 | 10.05 | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 43.6 | 7.42 | 10.25 | A. Sonntag and v. Mueller. | Smithsonian Cont's to Know., Wash., 1860. |
| ---- | 44.25 | 7.367 | 10.28 | Do. | C. S. Rpt., 1856, p. 214. |
| 10.29 | | | | S. M. Ackley. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | 44.8 | 7.37 | 10.39 | A. Sonntag and v. Mueller. | C. S. Rpt., 1856, p. 214 & Smithsonian Cont's to Know., Wash., 1860. |
| ---- | 44.2 | 7.39 | 10.31 | Do. | Smithsonian Cont's to Know., Wash., 1860. |
| ---- | | | | Don Alzate. | Encyc. Met., London, 1848, Art. Magnetism. |
| ---- | | | | A. v. Humboldt. | Do. |
| 9.96 | 45.0 | 7.440 | 10.49 | Do. | Rpt. Brit. Asso., Vol. VI, 1838, and Bequerel's Traité du Magnétisme, Paris, 1846. H and F very uncertain; C. S. Rpt., 1861, App. 22. |
| 10.105 | | | | A. Sonntag and v. Mueller. | C. S. Rpt., 1856, p. 214, and Smithsonian Cont's to Know., 1860. |
| 10.553 | | | | V. Reyes. | Memoria sobre el Dept. Magnetico, &c., Mexico, 1880. |
| ---- | ---- | ---- | ---- | M. Barcena. | Communication of Mexican Consul at San Francisco to Assist. G. Davidson. |
| 10.48 | 46.50 | 7.205 | 10.47 | S. M. Ackley. | C. & G. S. Rpt., 1881, App. 9. |
| 10.78 | 49.03 | 7.066 | 10.78 | ---- | Do. |
| ---- | | | | Don A. Malaspina. | Bode's Astr. Jahrb., Berlin, 1828. |
| ---- | | | | Du Petit Thouars. | Phil. Trans. R. S., 1875, Sir E. Sabine. |
| ---- | | | | E. Belcher. | Phil. Trans. R. S., 1843 and 1875. |
| 10.66 | 46.4 | 7.184 | 10.42 | Do. | Phil. Trans. R. S., 1875. |
| ---- | | | | Do. | Phil. Trans. R. S., 1843 and 1875. |
| 10.43 | | | | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | ---- | ---- | ---- | Barnett. | Phil. Trans. R. S., 1875. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| 10.63 | 47.5 | 7.083 | 10.48 | E. Belcher. | Phil. Trans. R. S., 1843 and 1875. |
| 10.49 | | | | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| 10.36 | 47.5 | 6.95 | 10.29 | W. Eimbeck and G. Davidson. | Do. |
| ---- | | | | Du Petit Thouars. | Phil. Trans. R. S., 1875. |
| 10.75 | 48.38 | 7.029 | 10.58 | E. Belcher. | Phil. Trans. R. S., 1843 and 1875. |
| 10.59 | | | | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| 10.74 | 49.29 | 7.003 | 10.74 | Do. | Do. |
| 10.67 | 49.93 | 6.865 | 10.66 | Do. | Do. |
| ---- | | | | Du Petit Thouars. | Phil. Trans. R. S., 1875. |
| 10.75 | | | | E. Belcher. | Phil. Trans. R. S., 1843 and 1875. |
| 10.837 | 48.44 | 6.99 | 10.54 | W. Harkness. | Smithsonian Cont's to Know., No. 239, Wash., 1873. |
| 10.38 | | | | W. Eimbeck and G. Davidson. | C. & G. S. Rpt., 1881, App. 9. |
| 10.57 | | | | H. E. Nichols. | Do. |

**TABLE I.—*Observed magnetic dips and horizontal and total magnetic***

MEXICO AND CENTRAL AMERICA—Continued.

| Name of station. | Latitude φ. | West longitude λ. | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Isle San Josef, Lower California. | 24 55.0 | 110 37.3 | 1881 | Jan. 31; Feb. 1. | 49 38.5 | 6.838 |
| Loreto, Lower California. | 26 01.1 | 111 20.5 | 1881 | Jan. 27, 28. | 51 00.8 | 6.789 |
| Pequeña Bay, Lower California. | 26 15.9 | 112 28.5 | 1881 | Feb. 28. | 51 48.1 | 6.689 |
| Santa Barbara Bay, Mexico. | 26 41.5 | 109 38.4 | 1880 | Dec. 22, 23. | 52 21.2 | 6.735 |
| Point Abreojos, Lower Cal. | 26 47.0 | 113 31.2 | 1881 | Mar. 2, 3. | 51 47.7 | 6.705 |
| Mulege, Lower Cal. | 26 53.8 | 111 58.2 | 1881 | Jan. 24, 25. | 52 05.5 | 6.724 |
| Ascension Island. | 27 06.0 | 114 18.4 | 1881 | Mar. 4, 5. | 51 43.4 | 6.710 |
| Santa Maria Cove, Lower Cal. | 27 25.2 | 112 19.5 | 1881 | Jan. 19, 20. | 52 56.8 | 6.681 |
| Saint Bartholomew. | 27 39.6 | 114 53 | 1839 | ---- | 51 41 | 6.780 |
| Guaymas, Mexico. | 27 54.8 | 110 52.6 | 1880 | Dec. 27, 28. | 52 58.0 | 6.619 |
| Cerros Island, Lower Cal. | 28 03.9 | 115 11.5 | 1873 | Feb. 17. | 52 30.5? | 6.505 |
| Do. | 28 03.4 | 115 11.3 | 1881 | Mar. 7, 8. | 52 55.0 | 6.603 |
| Santa Teresa Bay, Lower Cal. | 28 25.1 | 112 51.9 | 1881 | Jan. 17, 18. | 53 49.0 | 6.571 |
| Guadalupe Island, Lower Cal. | 28 55.3 | 118 15.1 | 1881 | Mar. 18. | 53 38.9 | 6.421 |
| Tiburon Island, Mexico. | 29 11.5 | 112 27.0 | 1880–81 | Dec. 31; Jan. 1. | 54 59.2 | 6.477 |
| Presidio del Norte, Rio Grande. | 29 34 | 104 25 | 1852 | ---- | 55 41 | ---- |
| San Geronimo Island, Lower Cal. | 29 47.2 | 115 47.7 | 1881 | Mar. 23, 25. | 54 30.0 | 6.430 |
| San Luis Gonzales, Lower Cal. | 29 50.9 | 114 25.4 | 1881 | Jan. 14, 15. | 55 11.3 | 6.425 |
| San Quentin. | 30 22 | 115 58 | 1839 | ---- | 54 29.9 | 6.468 |
| San Martin Island, Lower Cal. | 30 29.4 | 116 07.2 | 1881 | Mar. 29, 30. | 55 34.4 | 6.377 |
| Point San Felipe, Lower Cal. | 31 02.1 | 114 49.8 | 1881 | Jan. 12, 13. | 56 25.2 | 6.272 |
| Rocky Point, Mexico. | 31 17.2 | 113 33.1 | 1881 | Jan. 4, 5. | 57 14.7 | 6.250 |
| Espia. | 31 21 | 107 56 | 1855 | Mar. 22. | 57 59 | 6.242 |
| Philipps' Point, Mexico. | 31 46.1 | 114 43.4 | 1881 | Jan. 8, 9, 10. | 57 31.8 | 6.184 |
| Todos Santos, Lower Cal. | 31 51.4 | 116 37.6 | 1881 | Apr. 2, 3. | 58 30.6 | 6.044 |

EASTERN SIBERIA.

| Name of station. | Latitude φ. | Longitude λ.* | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Petropavlovsk, Kamchatka. | 53 01 | 158 43 | 1779 | June and Sept. | 63 05 | ---- |
| Do. | 53 01 | 158 43 | 1804 | Sept. | 63 32 | ---- |
| Do. | 53 00 | 158 43.5 | 1827 | July. | 64 02 | ---- |
| Do. | 53 00 | 158 40 | 1827 | Sept. 30. | 64 07 | ---- |
| Do. | 53 00 | 158 40 | 1829 | Oct. 13. | 63 49 | ---- |
| Do. | 53 01 | 158 43 | 1837 | Sept. 4 and 5. | 64 05 | ---- |
| Do. | 53 00 | 158 43 | 1854 | July. | 64 47 | ---- |
| Do. | 53 00.6 | 158 39.2 | 1876 | June 12; Sept. 15. | 64 14 | ---- |

*A − sign indicates west longitude; a + sign indicates east longitude from Greenwich.

***intensities in the United States and adjacent regions.—Continued.***

MEXICO AND CENTRAL AMERICA—Continued.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| 10.56 | 49.75 | 6.819 | 10.55 | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| 10.79 | 51.12 | 6.770 | 10.79 | Do. | Do. |
| 10.82 | 51.91 | 6.671 | 10.81 | Do. | Do. |
| 11.03 | 52.47 | 6.714 | 11.02 | Do. | Do. |
| 10.84 | 51.86 | 6.688 | 10.83 | Do. | Do. |
| 10.94 | 52.16 | 6.707 | 10.93 | Do. | Do. |
| 10.83 | 51.79 | 6.693 | 10.82 | Do. | Do. |
| 11.09 | 53.02 | 6.664 | 11.08 | Do. | Do. |
| 11.20 | 53.0 | ---- | ---- | E. Belcher. | Phil. Trans. R. S., 1843 and 1875. |
| 10.99 | 52.97 | 6.601 | 10.96 | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| 10.69 | 52.95 | 6.586 | 10.93 | W. Eimbeck and G. Davidson. | Do. |
| 10.95 | | | | H. E. Nichols. | Do. |
| 11.13 | 53.82 | 6.554 | 11.10 | Do. | Do. |
| 10.83 | 53.72 | 6.404 | 10.82 | Do. | Do. |
| 11.29 | 55.08 | 6.459 | 11.28 | Do. | Do. |
| ---- | 55.6 | ---- | ---- | W. H. Emory. | U. S. & Mex. Bound. Sur., Am. Acad. Sc., Vol. VI, 1856. |
| 11.07 | 54.50 | 6.413 | 11.04 | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| 11.25 | 55.19 | 6.408 | 11.23 | Do. | Do. |
| 11.41 | ---- | ---- | ---- | E. Belcher. | Phil. Trans. R. S., 1843 and 1875. |
| 11.28 | 55.58 | 6.360 | 11.25 | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| 11.34 | 56.42 | 6.255 | 11.31 | Do. | o. |
| 11.55 | 57.24 | 6.233 | 11.52 | Do. | Do. |
| 11.77 | 57.9 | 6.11 | 11.50 | W. H. Emory. | U. S. & Mex. Bound. Sur., Am. Acad. Sc., Vol. VI, 1856. |
| 11.52 | 57.53 | 6.168 | 11.49 | H. E. Nichols. | C. & G. S. Rpt., 1881, App. 9. |
| 11.57 | 58.51 | 6.028 | 11.54 | Do. | Do. |

EASTERN SIBERIA.

| Total force F. | Referred results. | | | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | | |
| | ° | | | | |
| ---- | | | | J. King. | Voyage to the Pacific, London, 1784. |
| ---- | | | | A. J. v. Krusenstern. | Do. |
| ---- | | | | F. W. Beechey. | Voyage to the Pacific, 1825–28, London, 1831. |
| ---- | | | | F. P. Lütke. | Mémoires St. Petersburg Acad., 1838. |
| 11.25 | 64.0 | -------- | -------- | Ad. Erman. | Reise um die Erde, Berlin, 1835. Value of F deduced by M. Baker = 11.10. |
| 11.11 | | | | Du Petit Thouars. | Voyage autour du Monde, Paris, 1843. Value of F deduced by M. Baker. |
| ---- | | | | ---- | Frigate Aurora. |
| ---- | | | | M. L. Onazevich. | Russian publication, communicated by M. Baker. |

TABLE I.—*Observed magnetic dips and horizontal and total magnetic*

EASTERN SIBERIA—Continued.

| Name of station. | Latitude φ. | Longitude λ.* | Year. | Month. | Dip θ. | Horizontal force H. |
|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | | | ° ′ | |
| Natschika. | 53 07 | 157 25 | 1829 | ---- | 64 05 | ---- |
| Bering Island. | 55 14 | 165 52 | 1879 | Aug. | 66 35 | 4.539 |
| St. Lawrence Island. | 63 43 | —171 23 | 1879 | Aug. | 74 25 | 3.327 |
| Plover Bay, Port Providence. | 64 26 | —173 15 | 1849 | ---- | 75 10 | ---- |
| Do. | 64 22.4 | —173 21.5 | 1869 | Aug. 3, 5. | 74 38.8 | ---- |
| Do. | 64 22 | —173 21.5 | 1876 | July 21–27. | 74 55 | ---- |
| Do. | 64 22.0 | —173 21.5 | 1880 | Aug. 12; Sept. 13. | 74 46.4 | 3.262 |
| Ongayak. | 64 24 | —172 20 | 1849 | ---- | 75 25 | ---- |
| Konyam Bay. | 64 50 | —172 57 | 1879 | July. | 75 10 | 3.195 |
| Holy Cross Bay. | 65 28 | —178 32 | 1828 | ---- | 75 43 | ---- |
| Yandangah. | 65 29 | —170 50 | 1849 | ---- | 76 17 | ---- |
| Laurenne. | 65 32 | —171 40 | 1849 | ---- | 77 15 | ---- |
| St. Lawrence Bay. | 65 35 | —170 44 | 1879 | July. | 75 55 | 3.078 |
| Do. | 65 38 | —170 46 | 1828 | ---- | 76 36 | ---- |
| Do. | 65 37 | —170 40 | 1849 | .... | 76 37 | ---- |
| Big Diomede Island. | 65 44.9 | —169 04.4 | 1880 | Sept. 10. | 76 15.0 | 2.981 |
| Chagneen. | 65 45 | —170 30 | 1849 | ---- | 76 56 | ---- |
| Pitlekai. | 67 05 | —173 30 | 1878 | Sept. | 76 59 | 2.887 |
| Do. | 67 04 | —173 30 | 1878–9 | Winter. | 77 01 | 2.861 |
| Irkaipi. | 68 49 | 180 00 | 1878 | Sept. | 77 56 | 2.676 |
| Werkon River. | 69 53 | 173 32 | 1823 | ---- | 79 59 | ---- |
| Wrangell Land, Rodgers' Harbor. | 70 57 | —178 10 | 1881 | Sept. | 79 15 | ---- |
| Wrangell Land, Hooper's Cairn, east coast. | 71 04 | —177 40 | 1881 | Aug. 12. | 79 52.5 | ---- |

*A — sign indicates west longitude; a + sign indicates east longitude from Greenwich.

***intensities in the United States and adjacent regions.—Continued.***

EASTERN SIBERIA—Continued.

| Total force F. | Referred results. $\theta_{1885.0}$ | $H_{1885.0}$ | $F_{1885.0}$ | Observer. | Reference and remarks. |
|---|---|---|---|---|---|
| | ° | | | | |
| 11.45 | ---- | ---- | ---- | Ad. Erman. | Phil. Trans. R. S., 1872. |
| ---- | 66.5 | 4.54 | 11.39 | A. Wijkander. | L'expédition de la Vega, 1878–80, Stockholm, 1883. |
| ---- | 74.3 | 3.33 | 12.31 | Do. | Do. |
| ---- | | | | Moore. | Phil. Trans. R. S., 1872. |
| 12.12 | 74.7 | 3.26 | 12.35 | A. Hall. | Rpt. Sol. Eclipse, 1869, U. S. Nav. Obsy., Wash. |
| ---- | | | | M. L. Onazevich. | Russian publication, commun'd by M. Baker. |
| 12.42 | | | | W. H. Dall and M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | ---- | ---- | ---- | Moore. | Phil. Trans. R. S., 1872. |
| ---- | 75.1 | 3.20 | 12.44 | A. Wijkander. | L'expédition de la Vega, 1878–80, Stockholm, 1883. |
| 12.80 | ---- | ---- | ---- | F. P. Lütke. | Phil. Trans. R. S., 1872. |
| ---- | ---- | ---- | ---- | Moore. | Do. |
| ---- | ---- | ---- | ---- | Do. | Do. |
| ---- | | | | A. Wijkander. | L'expédition de la Vega, 1878–80, Stockholm, 1883. |
| 12.84 | 75.8 | 3.08 | 12.56 | F. P. Lütke. | Phil. Trans. R. S., 1872. |
| ---- | | | | Moore. | Do. |
| 12.54 | 76.2 | 2.98 | 12.49 | W. H. Dall and M. Baker. | C. & G. S. Rpt., 1881, App. 9. |
| ---- | ---- | ---- | ---- | Moore. | Phil. Trans. R. S., 1872. |
| ---- | 76.9 | 2.87 | 12.66 | A. Wijkander. | L'expédition de la Vega, 1878–80, Stockholm, 1883. |
| ---- | | | | Do. | Do. |
| ---- | 77.8 | 2.68 | 12.68 | Do. | Do. |
| ---- | ---- | ---- | ---- | Wrangell. | Phil. Trans. R. S., 1872. |
| ---- | 79.2 | ---- | ---- | Putnam. | ---- |
| ---- | 79.8 | ---- | ---- | C. L. Hooper. | Paper read before Geog. Soc., San Francisco, by Geo. Davidson, Dec., 1881. |

## PART II.

### SECULAR VARIATION OF THE MAGNETIC DIP IN THE UNITED STATES.

At the time of the appearance of Appendices Nos. 32 and 33, Coast Survey Report for the year 1856, which contain a first discussion, by the writer, of observed dips, the facts known respecting the secular variation of the dip within the limits of the United States were very meager and in part conjectural. Prof. E. Loomis appears to have been the first to give attention to the subject. He remarks (Silliman's Journal, 1838), "From the course of the observations made in other places by Professor Bache it may be inferred that the dip in 1834 was at Cambridge 73° 33′, being an increase since 1783 of 3° 52′, or about 4½′ per year. It may be considered as established that the dip has increased in this country since the earliest observations, but whether it is still increasing at the present time seems more uncertain."

"The observations made at Albany and New York may excite a suspicion that such is not the fact. It is hoped that so important a question will not long remain doubtful."

It may be remarked to this that the supposed increase in the dip must probably be referred back to the first quarter or earlier part of the present century, and that the Cambridge observations of 1780–'83 are looked upon with doubt as to their reliability; at any rate they cannot be reconciled with our present knowledge of the secular change. It is true they were formerly supposed the earliest known recorded dips in the country, a distinction which now must be accorded, however, to Unalashka (1778), but there were no other observations on or near our Atlantic coast till 1822, thus cutting off the means of comparison and verification. In his second collection of dips (Silliman's Journal, 1840), Professor Loomis arrives atm ore certain results by comparing Long's dips of 1819 with others of 1839, where he notices a difference of 30′, and says, "In the absence, then, of more accurate data we may call this the diminution of the dip from 1819 to 1839, being at the rate of 1.′5 per year." Again, comparing the dips in New York by Sir E. Sabine and Sir J. Franklin (1822 to 1825) with his own and others about the epoch 1835, he finds a difference of 25′ and concludes a diminution of 2.′1 per annum and assumes the mean between the two determinations, or 1.′8, to be the annual diminution of the dip for the (Eastern) United States.

Taking up the subject in 1856, I showed that in the Northeastern part of the country the dip continued to decrease till about the year 1843, when the dip became stationary; the occurrence of this mimimum was fixed at 1842.7±0.7, and it was further shown that since the reversal of the motion at that epoch the dip had already attained, in 1856, an average annual increase of 2.′7, and it was conjectured that the formulæ given for the secular variation would apply for ten or fifteen years after this minimum epoch. Subsequent observations, however, did not verify this range of applicability, as we shall presently see. This *increase* of the dip became first apparent at the magnetic observatory at Toronto, Canada, and Colonel Sabine remarks (Vol. II of the Toronto Observations, London, 1853): "On a first inspection of the values of the inclination in the years from 1841 to 1852, inclusive, we might be led to infer that in 1843 or 1844 the secular change at Toronto reached a turning epoch, and that from having been previously a decrease it became subsequently an increase of inclination. It is possible, however, that the facts may admit, and may hereafter receive, a different explanation." In the year 1855 Prof. Chr. Hansteen published three articles in the Astronomische Nachrichten (Nos. 947, 948, and 954) "On the variations of the magnetic inclination in the northern temperate zone." To these papers reference was made by me in 1856, since they include the two stations, New York and Sitka. For the former place the analytical formula produces a maximum for 1822.3±1.1; I am, however, inclined to think that this maximum happened earlier. For the latter place his formula gives a minimum in 1838.8±6.4, but I think there is little probability that this has any relation to the minimum noticed at stations in the Eastern section of the country.

Coming now to later researches, the occurrence of this minimum about 1840 to 1844 was certainly as unexpected as subsequently the sudden stoppage of the increasing dip about 1859 in the Eastern part of the United States. Reasoning by analogy from what we knew of the long period of the secular variation in the declination and the long continued variation in the dip at certain stations, tho' not within our geographical limits, it was reasonable to expect that the increase in the dip would continue to be observed at least for many years. This idea, however, was quickly dispelled and since about 1860 the dip in nearly all parts of the United States has again resumed the direction of diminishing value, thus suggesting the idea of a *secondary* motion or wave of comparatively short duration and of a character opposite to the general motion in the variation of the dip, as it existed before and after this temporary interruption. The observations made at Washington (see Coast Survey Report for 1870, Appendix No. 14) first indicated, in 1860, a change in the sign of the annual progression, which change was soon confirmed by the observations at Eastport, Me., at Key West, Fla., and at Toronto, Canada. At Washington and Toronto the former annual increase ceased about 1859, and the annual decrease, which soon after set in, seems to have rapidly spread over the whole country, though apparently it only reached Southern California at a much later time. *An annual diminution is now the rule* and it applies also to Canada and a part of the British North American Possessions; thus at Lake Athabasca, Sir J. H. Lefroy remarks in his "Diary of a Magnetic Survey of a Portion of the Dominion of Canada, chiefly in the Northwestern Territories, etc." (London, 1883): "If we may assume that this element (the dip) attained its maximum value at Lake Athabasca at the same epoch as it did at Toronto (1859) it was probably again the same in 1874 as it was in 1844, and we have, therefore, for the present rate of secular change of dip in that quarter —1.′7 per annum."

When we enter more minutely into the investigation of the law of secular change we find the same to be dependent, as in the case of the change in declination, on the latitude and longitude of the place, and it will be desirable to divide the total geographical area into separate areas possessing a similar characteristic with respect to the secular variation. An examination of the figures of Table II (given further on) which were extracted from the general Table I, will show the difficulty in recognizing the true law of change in consequence of obscuration by defective values, due either to indifferent observations, to defective needles, or more generally to local effects from change of place. To overcome this difficulty the dips at the various places and included in a certain region were plotted on the same scale and for the same time ordinates, by which means it became possible to recognize any common feature as well as any defective observation, yet considerable difficulties were encountered in understanding and extracting the law from scanty, conflicting, or otherwise confusing data, as those, for instance, in the West Indies and California. With but a very few exceptions we have to contend with an insufficient number of observations as well as with a want of equal distribution in time, even over the short period at present at our command, nor can we feel quite sure of having seized the correct interpretation in all cases.

We shall first give in tabular form, and conveniently arranged for computation, the observed dips at leading stations, selected from those of Table I in consequence of their fitness for the investigation of the secular variation or of the present annual change. For some of these stations the dips have also been expressed by means of an exponential function (as had been done in 1856). Such expressions apply only for a very limited time but they will enable us to refer observations to any desired epoch, within their proper range of applicability, for which it may be intended to chart the isoclinics. In establishing these equations for dip we have used the method of least squares, and had also resort to otherwise interpolated values to fill up gaps in time or defects in extent of series, thus simply trying to make the best of imperfect material.

The formulæ involved may be briefly recapitulated as follows:

Let $\theta$ = the dip at any time $t$ where $t$ is expressed in years and fractions of a year. It is considered positive when the north end of the needle dips below the horizontal plane.

$\theta_0$ = the dip corresponding to the time $t_0$ for which epoch the year 1850 has been adopted in conformity with the paper in the Coast and Geodetic Survey Report for 1882, Appendix No 12, containing the discussion of the secular variation of the magnetic declination. We put

$$\theta = \theta_0 + y\,(t - t_0) + z\,(t - t_0)^2 + u\,(t - t_0)^3 + \ldots\ldots$$

or

$$\theta = \theta_1 + x + y\,.\,\triangle t + z\,.\,\triangle t^2 + u\,.\,\triangle t^3 + \ldots\ldots$$

where $\triangle t = t - 1850.0$ and $\theta_1$ and assumed value of $\theta_0$ and $x, y, z, u$ the correction and the factors to be determined from the observations themselves.

Each observation will furnish an equation of condition of the form

$$0 = \theta_1 - \theta + x + y \,.\, \triangle t + z \,.\, \triangle t^2 + u \,.\, \triangle t^3$$

stopping at terms involving the third power of the time. To facilitate the solution of the normal equations we introduce the quantities

$$\mathrm{X} = x \qquad \mathrm{Y} = 10y \qquad \mathrm{Z} = 10^2 z \qquad \mathrm{U} = 10^3 u$$

and multiply the first equation by $10^0$, the second by $10^1$, the third by $10^2$, and the fourth by $10^3$.

We also have:

$$\frac{d\,\theta}{d\,t} = y + 2\,z\,(t - t_0) + 3\,u\,(t - t_0)^2$$

hence the annual change

$$a = y + 2z \,.\, \triangle\, t + 3u \,.\, \triangle\, t^2$$

For condition of maximum or minimum, and for point of inflection we have

$$0 = y + 2\,z\,(t - t_0) + 3\,u\,(t - t_0)^2$$

$$\frac{d^2\theta}{d\,t^2} = 0 = 2\,z + 6\,u\,(t - t_0)$$

The time of maximum annual change is given by $\mathrm{T}_{11} = t_0 - \frac{z}{3\,u}$ and the times of maximum and of minimum dip by:

$$\mathrm{T} = t_0 - \frac{z}{3\,u} + \sqrt{\left(\frac{z}{3\,u}\right)^2 - \frac{y}{3\,u}} \qquad \mathrm{T}_1 = t_0 - \frac{z}{3\,u} - \sqrt{\left(\frac{z}{3\,u}\right)^2 - \frac{y}{3\,u}}$$

The probable error $\epsilon_0$ of a single value is found by

$$\epsilon_0 = 0.674\sqrt{\frac{\Sigma\,\triangle^2}{n - 4}}$$

The numerical application of the formulæ was only extended to a few selected stations which more or less admitted of it; the results follow the columns of tabular values and of observers.

TABLE II.—*Annual values of observed magnetic dip at prominent stations and comparison of observed and computed dips.*

| No. | Locality and observer. | Year and fraction. | Observed dip. | Computed dip. | Δθ O—C. |
|---|---|---|---|---|---|
| | *Halifax, Nova Scotia.* | | ° | ° | ° |
| 1 | Home. | 1834.4 | 75.55 | | |
| 2 | Home. | 1837.4 | 74.97 | | |
| 3 | Estcourt. | 1838.5 | 74.75 | | |
| 4 | Keely. | 1847.5 | 75.62 | | |
| 5 | Maclear and Bromley. | 1873.4 | 74.80 | | |
| 6 | Baylor. | 1879.7 | 74.65 | | |
| 7 | Very. | 1881.8 | 74.48 | | |
| | *Quebec, Canada.* | | | | |
| 1 | Lefroy. | 1842.7 | 77.26 | | |
| 2 | Younghusband. | 1845.5 | 77.15 | | |
| 3 | Schott. | 1859.5 | 77.29 | | |
| 4 | Baylor. | 1879.7 | 76.75 | | |
| | *Montreal, Canada.* | | | | |
| 1 | Back. | 1833.5 | 77.10 | | |
| 2 | Estcourt. | 1838.5 | 76.32 | | |
| 3 | Lefroy. | 1842.7 | 77.22 | | |
| | *Montreal, Canada*—Cont'd. | | ° | ° | ° |
| 4 | Lefroy. | 1843.3 | 77.15 | | |
| 5 | Younghusband. | 1845.5 | 77.14 | | |
| 6 | Schott. | 1859.5 | 76.86 | | |
| 7 | Baylor. | 1879.7 | 76.43 | | |
| | *Cambridge and Boston, Mass.* | | | | |
| | Williams. | 1780.9 | 69.85 (?) | | |
| | Williams. | 1782.4 | 69.68 (?) | | |
| | Williams. | 1783.9 | 69.68 (?) | | |
| 1 | Loomis and Bond. | 1839.7 | 74.31 | 74.25 | +.06 |
| 2 | Lovering and Bond. | 1840.5 | 74.36 | 74.26 | +.10 |
| 3 | Graham and Bond. | 1841.5 | 74.22 | 74.26 | −.04 |
| 4 | Locke, Lefroy, and Graham. | 1842.5 | 74.24 | 74.27 | −.03 |
| 5 | Graham. | 1844.9 | 74.30 | 74.29 | +.01 |
| 6 | Locke. | 1845.4 | 74.32 | 74.30 | +.02 |
| 7 | Lee and Fauntleroy. | 1846.7 | 74.21 | 74.31 | −.10 |
| 8 | Ives and Whipple. | 1850.6 | 74.57 | 74.36 | +.21 |

TABLE II.—*Annual values of observed magnetic dip at prominent stations and comparison of observed and computed dips.*—*Continued.*

| No. | Locality and observer. | Year and fraction. | Observed dip. | Computed dip. | Δθ O—C. |
|---|---|---|---|---|---|
| | *Cambridge and Boston, Mass.*—Cont'd. | | ° | ° | ° |
| 9 | Ives and Whipple. | 1854.4 | 74.55 | 74.40 | +.15 |
| 10 | Schott. | 1855.6 | 74.49 | 74.41 | +.08 |
| 11 | Friesach. | 1856.5 | 74.20 | 74.41 | −.21 |
| 12 | Smith (W. P.). | 1859.2 | 74.33 | 74.42 | −.09 |
| | Scott and Goodfellow. | 1872.8 | 73.52 (?) | 74.14 | −.62 |
| 13 | Baylor. | 1879.6 | 73.81 | 73.69 | +.12 |
| | *Providence, R. I.* | | | | |
| 1 | Bache. | 1834.6 | 74.05 | | |
| 2 | Loomis. | 1839.7 | 73.99 | | |
| 3 | Bache. | 1841.5 | 74.03 | | |
| 4 | Lefroy. | 1842.7 | 74.00 | | |
| 5 | Schott. | 1855.6 | 74.26 | | |
| 6 | Sherman. | 1884.5 | 73.28 | | |
| 7 | Baylor. | 1885.3 | 73.18 | | |
| | *New Haven, Conn.* | | | | |
| 1 | Loomis. | 1839.7 | 73.44 | 73.48 | −.04 |
| 2 | Locke and Lefroy. | 1842.5 | 73.48 | 73.49 | −.01 |
| 3 | Renwick. | 1844.7 | 73.40 | 73.51 | −.11 |
| | Fauntleroy. | 1847.8 | 74.28 (?) | 73.54 | +.74 |
| 4 | Ruth. | 1848.6 | 73.54 | 73.54 | .00 |
| 5 | Schott. | 1855.6 | 73.74 | 73.61 | +.13 |
| 7 | Thorpe. | 1878.5 | 73.09 | 73.20 | −.11 |
| 8 | Sherman. | 1884.5 | 72.83 | 72.79 | +.04 |
| 9 | Sherman. | 1885.3 | 72.79 | 72.70 | +.09 |
| | *Albany and Greenbush, N. Y.* | | | | |
| 1 | Henry and Cram. | 1833.3 | 74.85 | 74.76 | +.09 |
| 2 | Bache. | 1834.6 | 74.67 | 74.75 | −.08 |
| 3 | Loomis. | 1839.7 | 74.85 | 74.75 | +.10 |
| 4 | Nicollet and Bache. | 1841.6 | 74.67 | 74.76 | −.09 |
| 5 | Lefroy. | 1842.8 | 74.74 | 74.77 | −.03 |
| 6 | Locke. | 1844.4 | 74.69 | 74.79 | −.10 |
| 7 | Schott. | 1855.6 | 75.18 | 74.97 | +.21 |
| 8 | Friesach. | 1856.7 | 74.93 | 74.98 | −.05 |
| 9 | Dean. | 1858.4 | 74.93 | 75.00 | −.07 |
| 10 | Baylor. | 1879.8 | 74.32 | 74.48 | −.16 |
| | *West Point and Cold-Spring, N. Y.* | | | | |
| 1 | Courtenay and Henry. | 1833.3 | 73.43 | | |
| 2 | Courtenay. | 1834.5 | 73.62 | | |
| 3 | Loomis. | 1839.7 | 73.46 | | |
| 4 | Graham. | 1840.6 | 73.34 | | |
| 5 | Lefroy and Bartlett. | 1842.8 | 73.52 | | |
| 6 | Bache. | 1843.5 | 73.20 | | |
| 7 | Schott. | 1855.7 | 73.91 | | |
| | *New York, N. Y.* | | | | |
| 1 | Sabine. | 1822.9 | 73.01 | 73.39 | −.38 |
| 2 | Franklin. | 1825.2 | 73.45 | 73.23 | +.22 |
| 3 | Joslyn. | 1831.3 | 73.00 | 72.93 | +.07 |
| 4 | Back. | 1833.3 | 73.03 | 72.87 | +.16 |
| 5 | Bache. | 1834.6 | 72.86 | 72.84 | +.02 |
| 6 | Loomis. | 1839.7 | 72.87 | 72.75 | +.12 |
| 7 | Locke and Bache. | 1841.5 | 72.59 | 72.74 | −.15 |
| 8 | Lefroy and Locke. | 1842.7 | 72.61 | 72.74 | −.13 |
| 9 | Renwick, Graham, Lefroy, and Locke. | 1844.5 | 72.67 | 72.73 | −.06 |
| 10 | Renwick. | 1845.7 | 72.68 | 72.73 | −.05 |
| 11 | Locke and Norwegian officer. | 1846.6 | 72.66 | 72.73 | −.07 |
| | *New York, N. Y.*—Cont'd. | | ° | ° | ° |
| 12 | Kane and Sonntag. | 1853.4 | 72.93 | 72.77 | +.16 |
| 13 | Schott. | 1855.6 | 72.83 | 72.78 | +.05 |
| 14 | Scott and Goodfellow. | 1872.8 | 72.60 | 72.64 | −.04 |
| | *Sandy Hook, N. J.* | | | | |
| 1 | Renwick. | 1844.6 | 72.63 | | |
| 2 | Schott. | 1855.6 | 72.87 | | |
| 3 | Hilgard (T. C.). | 1873.8 | 72.49 | | |
| 4 | Baylor. | 1879.5 | 72.14 | | |
| | *Philadelphia, Pa.* | | | | |
| 1 | Bache and Courtenay. | 1834.5 | 72.00 | 72.03 | −.03 |
| 2 | Bache. | 1838.5 | 71.73 | 72.00 | −.27 |
| 3 | Loomis. | 1839.7 | 72.12 | 71.99 | +.13 |
| 4 | Bache. | 1840.7 | 71.88 | 71.99 | −.11 |
| 5 | Graham, Bache, and Locke. | 1841.6 | 71.98 | 72.00 | −.02 |
| 6 | Bache, Graham, Locke, and Lefroy. | 1842.5 | 72.00 | 72.00 | .00 |
| 7 | Bache. | 1843.6 | 71.97 | 72.01 | −.04 |
| 8 | Bache, Locke, and Graham. | 1844.3 | 71.99 | 72.01 | −.02 |
| 9 | Locke. | 1846.4 | 72.02 | 72.03 | −.01 |
| 10 | Schott. | 1855.7 | 72.29 | 72.16 | +.13 |
| 11 | Schott. | 1862.6 | 72.10 | 72.21 | −.11 |
| 12 | Scott and Goodfellow. | 1872.8 | 72.26 | 72.09 | +.17 |
| 13 | Baylor. | 1877.8 | 71.69 | 71.90 | −.21 |
| 14 | Smith (E.). | 1884.7 | 71.48 | 71.41 | +.07 |
| | *Baltimore, Md.* | | | | |
| 1 | Courtenay. | 1834.5 | 71.98 | 71.94 | +.04 |
| 2 | Loomis. | 1839.7 | 71.84 | 71.75 | +.09 |
| 3 | Bache. | 1840.6 | 71.57 | 71.73 | −.16 |
| 4 | Locke, Nicollet, and Graham. | 1841.6 | 71.70 | 71.71 | −.01 |
| 5 | Graham and Lefroy. | 1842.7 | 71.69 | 71.68 | +.01 |
| 6 | Graham. | 1844.5 | 71.60 | 71.67 | −.07 |
| 7 | Schott. | 1856.7 | 71.76 | 71.71 | +.05 |
| 8 | Baylor. | 1877.8 | 71.61 | 71.58 | +.03 |
| | *Washington and District of Columbia.* | | | | |
| 1 | Wilkes. | 1838.5 | 71.22 | 71.39 | −.17 |
| 2 | Wilkes and Loomis. | 1839.4 | 71.32 | 71.39 | −.07 |
| 3 | Gilliss. | 1840.5 | 71.34 | 71.39 | −.05 |
| 4 | Gilliss, Bache, Nicollet, and Graham. | 1841.5 | 71.29 | 71.39 | −.10 |
| 5 | Graham and Lefroy. | 1842.8 | 71.22 | 71.39 | −.17 |
| 6 | Locke and Graham. | 1844.3 | 71.36 | 71.39 | −.03 |
| 7 | Lee (T. J.). | 1845.4 | 71.57 | 71.39 | +.18 |
| 8 | Dean and Bache. | 1851.4 | 71.32 | 71.38 | −.06 |
| 9 | Hilgard (J. E.). | 1852.4 | 71.27 | 71.37 | −.10 |
| 10 | Gilliss. | 1853.4 | 71.36 | 71.37 | −.01 |
| 11 | Schott. | 1855.6 | 71.47 | 71.36 | +.11 |
| 12 | Schott. | 1856.6 | 71.34 | 71.35 | −.01 |
| 13 | Reed. | 1857.2 | 71.38 | 71.34 | +.04 |
| 14 | Schott. | 1858.4 | 71.38 | 71.34 | +.04 |
| 15 | Schott. | 1859.5 | 71.41 | 71.32 | +.09 |
| 16 | Schott. | 1860.7 | 71.27 | 71.31 | −.04 |
| 17 | Walker. | 1861.5 | 71.30 | 71.30 | .00 |
| 18 | Schott. | 1862.6 | 71.31 | 71.29 | +.02 |
| 19 | Schott. | 1863.6 | 71.24 | 71.27 | −.03 |
| 20 | Schott. | 1865.5 | 71.20 | 71.24 | −.04 |
| 21 | Schott, Goodfellow, and Harkness. | 1867.5 | 71.14 | 71.20 | −.06 |

**TABLE II.**—*Annual values of observed magnetic dip at prominent stations and comparison of observed and computed dips.*—*Continued.*

| No. | Locality and observer. | Year and fraction. | Observed dip. | Computed dip. | Δθ O−C. |
|---|---|---|---|---|---|
| | *Washington and District of Columbia*—Cont'd. | | ° | ° | ° |
| 22 | Schott. | 1868.5 | 71.06 | 71.18 | −.12 |
| 23 | Schott and Hall. | 1869.4 | 70.99 | 71.16 | −.17 |
| 24 | Schott. | 1870.5 | 70.92 | 71.13 | −.21 |
| 25 | Schott. | 1871.5 | 71.00 | 71.11 | −.11 |
| 26 | Schott. | 1872.5 | 71.01 | 71.08 | −.07 |
| 27 | Schott. | 1873.5 | 70.97 | 71.05 | −.08 |
| 28 | Schott. | 1874.5 | 70.88 | 71.02 | −.14 |
| 29 | Schott. | 1875.5 | 70.85 | 70.98 | −.13 |
| 30 | Schott. | 1876.3 | 70.79 | 70.95 | −.16 |
| 31 | Schott. | 1877.5 | 70.82 | 70.91 | −.09 |
| 32 | Schott and Thorpe. | 1878.6 | 70.80 | 70.86 | −.06 |
| 33 | Eimbeck and Schott. | 1879.5 | 70.81 | 70.82 | −.01 |
| 34 | Baylor. | 1880.5 | 70.75 | 70.78 | −.03 |
| 35 | Very. | 1881.7 | 70.71 | 70.72 | −.01 |
| 36 | Eimbeck and Colonna. | 1882.6 | 70.76 | 70.68 | +.08 |
| 37 | Schott. | 1883.5 | 70.68 | 70.63 | +.05 |
| 38 | Maxfield, Eimbeck, and Schott. | 1884.2 | 70.62 | 70.59 | +.03 |
| 39 | Schott. | 1885.5 | 70.55 | 70.52 | +.03 |
| | *Pittsburg and Allegheny, Pa.* | | | | |
| 1 | Long. | 1819.3 | 73.20 | | |
| 2 | Loomis. | 1839.7 | 72.65 | | |
| 3 | Bache. | 1840.6 | 72.54 | | |
| 4 | Locke. | 1841.2 | 72.72 | | |
| 5 | Locke. | 1842.3 | 72.72 | | |
| 6 | Locke. | 1845.3 | 72.78 | | |
| 7 | Thorpe. | 1878.7 | 72.12 | | |
| | *Toronto, Canada.* | | | | |
| 1 | Riddell and Younghusband. | 1841.5 | 75.28 | 75.27 | +.01 |
| 2 | Younghusband and Lefroy. | 1842.5 | .27 | .28 | −.01 |
| 3 | Younghusband and Bache. | 1843.5 | .24 | .28 | −.04 |
| 4 | Younghusband, Lefroy, and Locke. | 1844.5 | .25 | .28 | −.03 |
| 5 | Lefroy. | 1845.5 | .26 | .29 | −.03 |
| 6 | Lefroy. | 1846.5 | .25 | .29 | −.04 |
| 7 | Lefroy. | 1847.5 | .26 | .30 | −.04 |
| 8 | Lefroy. | 1848.5 | .30 | .31 | −.01 |
| 9 | Lefroy. | 1849.5 | .31 | .32 | −.01 |
| 10 | Lefroy. | 1850.5 | .33 | .32 | +.01 |
| 11 | Lefroy. | 1851.5 | .34 | .33 | +.01 |
| 12 | Lefroy. | 1852.5 | .34 | .34 | .00 |
| 13 | Lefroy and Kingston. | 1853.5 | .37 | .35 | +.02 |
| 14 | Kingston. | 1854.5 | .38 | .36 | +.02 |
| 15 | Kingston. | 1855.5 | .39 | .36 | +.03 |
| 16 | Kingston. | 1856.5 | .40 | .37 | +.03 |
| 17 | Kingston. | 1857.5 | .40 | .38 | +.02 |
| 18 | Kingston. | 1858.5 | .41 | .38 | +.03 |
| 19 | Kingston and Smith (W. P.). | 1859.5 | .42 | .39 | +.04 |
| 20 | Kingston. | 1860.5 | .41 | .39 | +.02 |
| 21 | Kingston. | 1861.5 | .40 | .40 | .00 |
| 22 | Kingston. | 1862.5 | .39 | .40 | −.01 |
| 23 | Kingston. | 1863.5 | .36 | .40 | −.04 |
| 24 | Kingston. | 1864.5 | .35 | .40 | −.05 |
| 25 | Kingston. | 1865.5 | .35 | .39 | −.04 |
| 26 | Kingston. | 1866.5 | .32 | .39 | −.07 |
| 27 | Kingston. | 1867.5 | .31 | .38 | −.07 |

| No | Locality and observer. | Year and fraction. | Observed dip. | Computed dip. | Δθ O−C. |
|---|---|---|---|---|---|
| | *Toronto, Canada*—Cont'd. | | ° | ° | ° |
| 28 | Kingston. | 1868.5 | 75.33 | 75.37 | −.04 |
| 29 | Kingston. | 1869.5 | .28 | .36 | −.08 |
| 30 | Kingston. | 1870.5 | .27 | .34 | −.07 |
| 31 | Kingston. | 1871.5 | 75.28 | 75.30 | −.02 |
| 32 | Carpmael. | 1885.3 | 74.87 | 74.84 | +.03 |
| | *Cleveland, Ohio.* | | | | |
| 1 | Loomis. | 1839.4 | 73.43 | 73.22 | +.21 |
| 2 | Loomis. | 1840.5 | 73.24 | 73.21 | +.03 |
| 3 | Loomis. | 1841.6 | 73.07 | 73.20 | −.13 |
| 4 | Younghusband. | 1842.8 | 73.06 | 73.20 | −.14 |
| 5 | Locke. | 1843.6 | 73.13 | 73.20 | −.07 |
| 6 | Smith (W. P.). | 1859.5 | 73.33 | 73.27 | +.06 |
| 7 | Goodfellow. | 1871.8 | 73.16 | 73.25 | −.09 |
| 8 | Lee (A. N.). | 1872.5 | 73.12 | 73.23 | −.11 |
| 9 | Lee (A. N.), | 1873.5 | 73.13 | 73.22 | −.09 |
| 10 | Baylor. | 1880.5 | 73.04 | 73.01 | +.03 |
| | *Detroit, Mich.* | | | | |
| 1 | Loomis. | 1839.4 | 73.71 | 73.61 | +.10 |
| 2 | Loomis and Nicollet. | 1841.7 | 73.57 | 73.60 | −.03 |
| 3 | Younghusband. | 1842.8 | 73.48 | 73.60 | −.12 |
| 4 | Locke. | 1843.4 | 73.54 | 73.60 | −.06 |
| 5 | Lefroy. | 1845.5 | 73.65 | 73.61 | +.04 |
| 6 | Smith (W. P.). | 1859.3 | 73.68 | 73.68 | .00 |
| 7 | Smith (W. P.). | 1860.4 | 73.72 | 73.69 | +.03 |
| 8 | Lee (A. N.). | 1872.4 | 73.58 | 73.64 | −.06 |
| 9 | Lee (A. N.). | 1873.4 | 73.57 | 73.63 | −.06 |
| 10 | Bailey. | 1876.4 | 73.57 | 73.57 | .00 |
| | *Cincinnati, Ohio.* | | | | |
| 1 | Locke. | 1838.2 | 70.62 | | |
| 2 | Locke. | 1840.7 | 70.47 | | |
| 3 | Locke and Loomis. | 1841.6 | 70.45 | | |
| 4 | Locke. | 1842.2 | 70.42 | | |
| 5 | Locke. | 1843.6 | 70.42 | | |
| 6 | Locke. | 1844.4 | 70.44 | | |
| 7 | Locke. | 1845.3 | 70.43 | | |
| 8 | Lefroy. | 1849.4 | 70.48 | | |
| 9 | Baylor. | 1880.9 | 70.41 | | |
| | *Madison, Wis.* | | | | |
| 1 | Locke. | 1839.8 | 74.06 | | |
| 2 | Loomis. | 1841.7 | 74.11 | | |
| 3 | Hilgard (F. E.). | 1876.8 | 73.91 | | |
| 4 | Braid. | 1877.7 | 73.92 | | |
| 5 | Suess and Baylor. | 1878.8 | 73.93 | | |
| 6 | Mason. | 1879.7 | 73.84 | | |
| 7 | Mason. | 1880.7 | 73.78 | | |
| 8 | Suess. | 1881.9 | 73.80 | | |
| | *Saint Louis, Mo.* | | | | |
| | Long. | 1819.5 | 70.50 (?) | 69.99 | + .51 |
| 1 | Nicollet. | 1836.0 | 69.17 | 69.47 | − .30 |
| 2 | Locke. | 1839.7 | 69.52 | 69.46 | + .06 |
| 3 | Loomis and Nicollet. | 1841.7 | 69.44 | 69.47 | − .03 |
| | Friesach. | 1856.8 | 68.02 (?) | 69.64 | −1.62 |
| 4 | Hilgard (T. C.). | 1872.5 | 69.57 | 69.56 | + .01 |
| 5 | Nipher. | 1878.4 | 69.31 | 69.34 | − .03 |
| | *Nassau, New Providence Island.* | | | | |
| 1 | Barnett. | 1841.5 | 56.22 | | |
| 2 | Barnett. | 1843.5 | 56.38 | | |
| 3 | Ackley. | 1879.1 | 55.84 | | |

TABLE II.—*Annual values of observed magnetic dip at prominent stations and comparison of observed and computed dips.*—*Continued.*

| No. | Locality and observer. | Year and fraction. | Observed dip. | Computed dip. | Δθ O−C. |
|---|---|---|---|---|---|
| | *Havana, Cuba.* | | ° | ° | ° |
| | Humboldt. | 1801.0 | 53.37 (?) | | |
| 1 | Sabine. | 1822.5 | 51.92 | | |
| 2 | Friesach. | 1857.1 | 52.00 | | |
| 3 | Ackley. | 1879.2 | 52.30 | | |
| | *Saint Thomas, West Indies.* | | | | |
| 1 | Zahrtmann. | 1834.5 | 49.48 | | |
| 2 | Schomburgh. | 1846.5 | 49.67 | | |
| 3 | Friesach. | 1857.1 | 48.50 | | |
| 4 | Harkness. | 1865.9 | 49.63 | | |
| | *Panama, United States of Columbia.* | | | | |
| 1 | Malaspina. | 1790.8 | 29.48 | | |
| 2 | Belcher. | 1837.5 | 31.86 | | |
| 3 | Haig. | 1858.3 | 32.50 | | |
| 4 | Harkness. | 1866.4 | 31.93 | | |
| | *Acapulco, Mexico.* | | | | |
| 1 | Malaspina. | 1791.3 | 36.12 | | |
| 2 | Humboldt. | 1803.2 | 38.88 | | |
| 3 | Belcher. | 1838.5 | 37.96 | | |
| 4 | Harkness. | 1866.4 | 39.90 | | |
| 5 | Nichols. | 1880.9 | 40.14 | | |
| | *Mexico, Mexico.* | | | | |
| 1 | Alzate. | 1778.5 | 38.00 | | |
| 2 | Humboldt. | 1799.5 | 42.17 | | |
| 3 | Humboldt. | 1803.9 | 42.17 | | |
| | Sonntag and Mueller. | 1857.9 | 41.43 (?) | | |
| 4 | Reyes. | 1879.8 | 44.86 | | |
| 5 | Barcena. | 1884.3 | 45.01 | | |
| | *San Blas, Mexico.* | | | | |
| 1 | Malaspina. | 1791.3 | 43.19 | | |
| 2 | Belcher. | 1837.5 | 45.40 | | |
| 3 | Belcher | 1838.5 | 44.60 | | |
| 4 | Belcher. | 1839.5 | 44.54 | | |
| 5 | Nichols. | 1880.9 | 46.35 | | |
| | *Magdalena Bay, Lower California.* | | | | |
| | Du Petit Thouars. | 1837.5 | 50.72 (?) | | |
| 1 | Belcher. | 1839.5 | 46.57 | | |
| 2 | Harkness. | 1866.4 | 48.53 | | |
| 3 | Eimbeck. | 1873.2 | 48.15 | | |
| 4 | Nichols. | 1881.1 | 48.31 | | |
| | *San Diego, Cal.* | | | | |
| | Vancouver. | 1793.9 | 59.22 (?) | | |
| 1 | Belcher. | 1839.5 | 57.10 | | |
| 2 | Emory. | 1849.5 | 57.55 | | |
| 3 | Trowbridge. | 1853.8 | 57.64 | | |
| 4 | Harkness. | 1866.5 | 57.90 | | |
| 5 | Throckmorton. | 1872.9 | 57.95 | | |
| 6 | Nichols. | 1881.3 | 57.85 | | |
| | *Los Angeles, Cal.* | | | | |
| 1 | Baker. | 1882.8 | 59.51 | | |
| 2 | Baker. | 1883.5 | 59.51 | | |
| 3 | Baker and Terry, jr. | 1884.5 | 59.49 | | |
| 4 | Terry, jr. | 1885.3 | 59.50 | | |

| No. | Locality and observer. | Year and fraction. | Observed dip. | Computed dip. | Δθ O−C. |
|---|---|---|---|---|---|
| | *Santa Barbara, Cal.* | | ° | ° | ° |
| | Douglas. | 1831.4 | 60.80 (?) | | |
| 1 | Belcher. | 1839.5 | 58.90 | | |
| 2 | Davidson and Throckmorton. | 1869.9 | 59.27 | | |
| 3 | Nichols. | 1881.3 | 59.32 | | |
| | *Monterey, Cal.* | | | | |
| 1 | Malaspina. | 1791.7 | 60.94 | | |
| | Vancouver. | 1792.9 | 63.01 (?) | | |
| | Vancouver. | 1794.9 | 63.00 (?) | | |
| | Golovnin. | 1818.7 | 54.25 (?) | | |
| 2 | Douglas. | 1831.0 | 62.12 | | |
| 3 | Belcher. | 1839.5 | 61.06 | | |
| 4 | Perry. | 1843.7 | 61.98 | | |
| 5 | Trowbridge. | 1854.4 | 60.99 | | |
| 6 | Throckmorton. | 1873.7 | 61.21 | | |
| 7 | Nichols. | 1881.3 | 61.21 | | |
| | *San Francisco, Cal.* | | | | |
| 1 | Kotzebue. | 1815.8 | 62.77 | | |
| 2 | Douglas. | 1831.1 | 62.97 | | |
| 3 | Belcher. | 1837.5 | 61.90 | | |
| 4 | Belcher. | 1839.5 | 62.10 | | |
| 5 | Davidson and Roe. | 1852.1 | 62.35 | | |
| 6 | Friesach. | 1858.4 | 62.78 | | |
| 7 | Harkness. | 1866.5 | 62.37 | | |
| 8 | Davidson, Throckmorton, and Eimbeck. | 1873.9 | 62.08 | | |
| 9 | Dall, Baker, and Nichols. | 1880.7 | 62.31 | | |
| 10 | Eimbeck, Marr, Nichols, and Lawson. | 1881.5 | 62.38 | | |
| 11 | Davidson and Marr. | 1884.7 | 62.34 | | |
| | *Cape Disappointment, Wash. Terr.* | | | | |
| 1 | Douglas. | 1830.8 | 69.50 | | |
| 2 | Belcher. | 1839.5 | 69.45 | | |
| 3 | Eimbeck. | 1873.8 | 69.23 | | |
| 4 | Nichols. | 1881.8 | 69.30 | | |
| | *Fort Vancouver, Wash. Terr.* | | | | |
| 1 | Douglas. | 1830.9 | 69.66 | | |
| 2 | Belcher. | 1839.5 | 69.37 | | |
| 3 | Haig. | 1860.3 | 69.29 | | |
| | *Nootka Sound, Vancouver Island.* | | | | |
| 1 | Cook. | 1778.3 | 72.48 | | |
| 2 | Malaspina. | 1791.6 | 70.35 | | |
| 3 | Vancouver. | 1792.8 | 73.93 | | |
| 4 | Nichols. | 1881.7 | 71.55 | | |
| | *York Factory, British N. A.* | | | | |
| 1 | Lefroy. | 1843.6 | 83.79 | | |
| 2 | Rae. | 1846.1 | 83.71 | | |
| 3 | Rae. | 1847.7 | 83.78 | | |
| 4 | Blakiston. | 1857.6 | 83.88 | | |
| 5 | Klotz. | 1884.7 | [illegible]8 | | |
| | *Norway House, British N. A.* | | | | |
| | Franklin. | 1819.8 | 83.67 (?) | | |
| 1 | Lefroy. | 1844.1 | 81.17 | | |
| 2 | Klotz. | 1884.6 | 81.21 | | |

TABLE II.—*Annual values of observed magnetic dip at prominent stations and comparison of observed and computed dips.*—Continued.

| No. | Locality and observer. | Year and fraction. | Observed dip. | Computed dip. | Δθ O—C. |
|---|---|---|---|---|---|
| | *Cumberland House, British N. A.* | | ° | ° | ° |
| | Franklin. | 1819.9 | 83.20(?) | | |
| | Franklin. | 1820.4 | 84.57(?) | | |
| 1 | Franklin. | 1825.5 | 80.35 | | |
| 2 | Lefroy. | 1844.1 | 80.42 | | |
| 3 | Klotz. | 1884.5 | 80.39 | | |
| | *Sitka, Alaska.* | | | | |
| | La Perouse. | 1786.6 | 73.50(?) | | |
| 1 | Golovnin. | 1818.5 | 76.55 | | |
| 2 | Lütke. | 1827.5 | 75.92 | | |
| 3 | Erman. | 1829.9 | 75.84 | | |
| 4 | Belcher. | 1837.5 | 75.86 | | |
| 5 | Belcher. | 1839.5 | 75.82 | | |
| 6 | Russian Observatory. | 1842.5 | 75.85 | | |
| 7 | Russian Observatory. | 1845.5 | 75.91 | | |
| 8 | Collinson. | 1851.0 | 76.33 | | |
| 9 | Dall and Baker. | 1880.4 | 75.20 | | |
| 10 | Nichols. | 1881.7 | 75.28 | | |
| | *Unalashka, Alaska.* | | | | |
| 1 | Cook. | 1778.8 | 69.39 | | |
| 2 | Kotzebue. | 1817.5 | 68.75 | | |
| | *Unalashka, Alaska*—Cont'd. | | ° | ° | ° |
| 3 | Lütke. | 1827.6 | 68.42 | | |
| 4 | Lütke. | 1829.5 | 68.43 | | |
| 5 | Tebenkoff. | 1849.5 | 68.37 | | |
| 6 | Dall and Baker. | 1880.7 | 67.60 | | |
| | *Port Clarence, Grantley Bay, Alaska.* | | | | |
| 1 | Collinson. | 1850.5 | 75.80 | | |
| 2 | Collinson and Maguire. | 1854.5 | 76.50 | | |
| 3 | Wijkander. | 1879.5 | 76.08 | | |
| 4 | Dall and Baker. | 1880.7 | 76.07 | | |
| | *Petropavlovsk, Kamchatka.* | | | | |
| 1 | King. | 1779.6 | 63.08 | | |
| 2 | Krusenstern. | 1804.7 | 63.53 | | |
| 3 | Beechey and Lütke. | 1827.6 | 64.08 | | |
| 4 | Erman. | 1829.8 | 63.82 | | |
| 5 | Du Petit Thouars. | 1837.7 | 64.08 | | |
| 6 | Officer of frigate Aurora. | 1854.5 | 64.78 | | |
| 7 | Onazevich. | 1876.6 | 64.23 | | |

The observations at Halifax, Quebec and Montreal are insufficient for presentation in an analytical form; but the latest observations at these places agree in indicating an apparently uniform decrease of dip between 1860 and 1880, viz:

$$\begin{aligned} &\text{At Halifax,} \quad a_{1860 \text{ to } 1882} = -2.3' \\ &\text{At Quebec,} \quad a_{1860 \text{ to } 1880} = -1.6 \\ &\text{At Montreal,} \quad a_{1858 \text{ to } 1880} = -1.2 \end{aligned}$$

The value of $a_{1885}$ is probably slightly greater in each case. There is a faint indication of the *secondary* minimum (about 1838 to 1844), referred to above.

For the stations Cambridge and Boston, New Haven, Albany and Greenbush, New York, Philadelphia, Baltimore, Washington, Toronto, Cleveland, Detroit and Saint Louis, we have a general likeness in the features of the secular variations, *i. e.*, they exhibit the *secondary* minimum, for which we find, on the average, the epoch 1840.5 ± 2.0 years, and they show the subsequent *secondary* maximum, which we find to have occurred, on the average, in 1860.0 ± 3.5 years. If this subordinate wave be persistent, its period would be about 39 ± 8 years. Its range is barely one-quarter of a degree.

After the occurrence of the maximum, and up to the present time, there is noted a regular decrease of dip at all the stations.

The following expressions were obtained for the stations, the second column giving the limit of applicability:

| Stations. | Limit. | Results. |
|---|---|---|
| Cambridge and Boston, Mass. | 1835 to 1885 | $\theta = 74^\circ.35 + .0120\,\Delta t - .000126\,\Delta t^2 - .0000350\,\Delta t^3$ |
| New Haven, Conn. | 1835 to 1885 | $\theta = 73.56 + .0108\,\Delta t - .000038\,\Delta t^2 - .0000274\,\Delta t^3$ |
| Albany and Greenbush, N. Y. | 1830 to 1885 | $\theta = 74.88 + .0170\,\Delta t + .000016\,\Delta t^2 - .0000350\,\Delta t^3$ |
| New York, N. Y. | 1820 to 1885 | $\theta = 72.75 + .0052\,\Delta t + .000243\,\Delta t^2 - .0000303\,\Delta t^3$ |
| Philadelphia, Pa. | 1830 to 1885 | $\theta = 72.08 + .0135\,\Delta t + .000158\,\Delta t^2 - .0000318\,\Delta t^3$ |
| Baltimore, Md. | 1830 to 1885 | $\theta = 71.66 + .0040\,\Delta t + .000819\,\Delta t^2 - .0000383\,\Delta t^3$ |
| Washington, D. C. | 1840 to 1885 | $\theta = 71.38 - .0025\,\Delta t - .000260\,\Delta t^2 - .0000100\,\Delta t^3$ |
| Toronto, Canada. | 1840 to 1885 | $\theta = 75.32 + .0079\,\Delta t + .000118\,\Delta t^2 - .0000208\,\Delta t^3$ |
| Cleveland, Ohio. | 1840 to 1885 | $\theta = 73.21 + .0055\,\Delta t + .000366\,\Delta t^2 - .0000250\,\Delta t^3$ |
| Detroit, Mich. | 1840 to 1885 | $\theta = 73.63 + .0057\,\Delta t + .000161\,\Delta t^2 - .0000175\,\Delta t^3$ |
| Saint Louis, Mo. | 1820 to 1885 | $\theta = 69.56 + .0127\,\Delta t + .000052\,\Delta t^2 - .0000270\,\Delta t^3$ |

We have, accordingly, the annual change $a_{1885}$ as follows:

| Station. | Annual change. | Station. | Annual change. |
|---|---|---|---|
| | ′ | | ′ |
| Cambridge and Boston. | −7.5 | Washington. | −3.5 |
| New Haven. | −5.6 | Toronto. | −2.5 |
| Albany and Greenbush. | −6.6 | Cleveland. | −3.6 |
| New York. | −5.4 | Detroit. | −2.8 |
| Philadelphia. | −5.5 | Saint Louis. | −5.0 |
| Baltimore. | −4.8 | | |

which values, in the absence of any additional information, may be used for a few years to come.

For use in connection with the secular variations of the horizontal component of the force and of the total force, we have formed two groups of stations, exhibiting for every fifth year since 1830 the dip as computed by the preceding formula. These groups are the same as those given further on in the discussion of the secular variation of the horizontal force, and the two averages are graphically exhibited on the accompanying diagram.

| Stations. | Jan. 1, 1830. | 1835. | 1840. | 1845. | 1850. | 1855. | 1860. | 1865. | 1870. | 1875. | 1880. | Jan. 1, 1885. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group I. | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| Cambridge, Mass. | 74.340 | 74.260 | 74.252 | 74.291 | 74.350 | 74.403 | 74.422 | 74.384 | 74.260 | 74.025 | 73.652 | 73.116 |
| New Haven, Conn. | 73.548 | 73.481 | 73.475 | 73.509 | 73.560 | 73.611 | 73.637 | 73.621 | 73.542 | 73.379 | 73.110 | 72.719 |
| New York, N. Y. | 72.985 | 72.829 | 72.752 | 72.734 | 72.750 | 72.778 | 72.796 | 72.781 | 72.709 | 72.559 | 72.307 | 71.932 |
| Sandy Hook, N. J.* | 72.865 | 72.709 | 72.632 | 72.614 | 72.630 | 72.658 | 72.676 | 72.661 | 72.589 | 72.439 | 72.187 | 71.812 |
| Albany, N. Y. | 74.826 | 74.746 | 74.747 | 74.799 | 74.880 | 74.961 | 75.017 | 75.020 | 74.946 | 74.769 | 74.459 | 73.995 |
| Average, type I. | 73.713 | 73.605 | 73.572 | 73.589 | 73.634 | 73.682 | 73.710 | 73.693 | 73.609 | 73.434 | 73.143 | 72.715 |

*Same as New York minus 0°.12, which is an average observed difference.

*Groups and stations.—Continued.*

| Stations. | Jan. 1, 1830. | 1835. | 1840. | 1845. | 1850. | 1855. | 1860. | 1865. | 1870. | 1875. | 1880. | Jan. 1, 1885. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group II. | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| Philadelphia, Pa. | 72.127 | 72.021 | 71.993 | 72.020 | 72.080 | 72.148 | 72.199 | 72.210 | 72.159 | 72.020 | 71.768 | 71.381 |
| Baltimore, Md. | 72.214 | 71.913 | 71.740 | 71.665 | 71.660 | 71.695 | 71.744 | 71.775 | 71.762 | 71.674 | 71.483 | 71.163 |
| Washington, D. C. | 71.406 | 71.393 | 71.389 | 71.387 | 71.380 | 71.361 | 71.319 | 71.251 | 71.146 | 71.000 | 70.801 | 70.547 |
| Toronto, Canada.* | 75.48 | 75.35 | 75.285 | 75.252 | 75.322 | 75.387 | 75.413 | 75.350 | 75.275 | 75.20 | 75.03 | 74.88 |
| Cleveland, Ohio. | 73.446 | 73.293 | 73.217 | 73.194 | 73.210 | 73.244 | 73.277 | 73.291 | 73.266 | 73.185 | 73.029 | 72.781 |
| Detroit, Mich. | 73.720 | 73.640 | 73.607 | 73.608 | 73.630 | 73.660 | 73.685 | 73.692 | 73.668 | 73.600 | 73.474 | 73.277 |
| Average, type II. | 73.066 | 72.935 | 72.872 | 72.854 | 72.880 | 72.916 | 72.939 | 72.928 | 72.880 | 72.780 | 72.598 | 72.338 |

* Values for 1830 and 1835 are interpolated.

Group III, composed of stations on the western coast, could not be established in consequence of the imperfections of the data, though it will be seen further on that the observations of the horizontal force admitted of such tabulation.

Turning to the Southern States and the West India Islands and Mexico, we find at Fernandina and Key West, Fla., the dip apparently to have been slowly decreasing since about 1860. In Louisiana it would seem that the dip has recently been stationary, the latest observations at New Orleans and Southwest Pass apparently pointing to a slight increase at present, whereas in Texas, at Dollar Point, near Galveston, observations show a decided increase of dip. Thus in passing from the eastern to the western gulf coast the present slight decrease in Florida vanishes and reverses in Louisiana, and becomes an increase in Texas. In other words, the subordinate extreme in these latitudes has just been passed in the east but has not yet been reached in the west.

In the West Indies and Mexico it is difficult to recognize what has been going on in the dip in consequence of the contradictory testimony of the observations, but forming a general idea of the change from comparison of all the stations it would appear that in the region bounded by Nassau, Havana, and Saint Thomas the dip is at present nearly stationary or persisting about an extreme phase. In Mexico and Central America, or in the region including Panama, Acapulco, Mexico, and San Blas, the data are more definite and the dip appears to have been *increasing* throughout this century, but the maximum has probably not yet been reached.

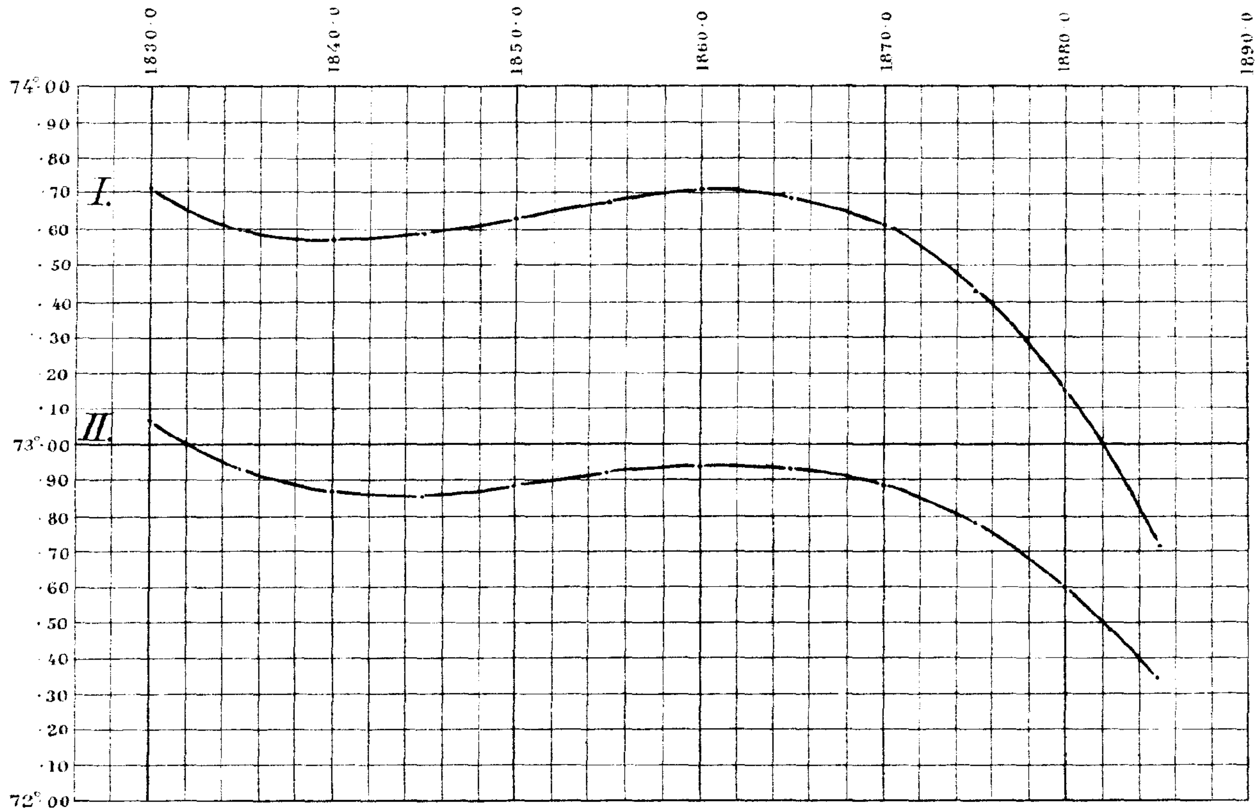
In connection with the above it may be stated that at Rio de Janeiro, Brazil, the change in the dip is no less remarkable than the change in the declination; we are here presented with a steady *increase* of north dip between La Caille's observation in 1751* (dip = $-20^\circ\ 0'$) and Harkness's observation in 1866 (dip = $-11^\circ\ 47'$), and the same phenomenon is noted at Valparaiso, Chili, between the observations of Malaspina* in 1793 (dip = $-44^\circ\ 58'$), and Harkness's observation of 1866 (dip = $-35^\circ\ 23'$). No such large changes have been observed within the area of the United States. At Havana the present annual change is probably less than $+0'.8$, at Acapulco about $+1'.0$, at Mexico and San Blas it may be $+1'.5$ to $+2'.0$, but at Magdalena Bay, Lower California, Mexico, the annual change seems to have become zero at present.

Passing north to the coast of California, Oregon, and Washington Territory we meet with several cases of embarrassing discordant observations; nevertheless we can clearly discern that at San Diego, Los Angeles, Santa Barbara, and Monterey the dip at present undergoes either no or but a very slight annual change. The state of the dip at San Francisco, at Cape Disappointment (mouth of the Columbia River), and at Fort Vancouver is probably just past the extreme and is very slowly decreasing, though we are unable to assign the amount.

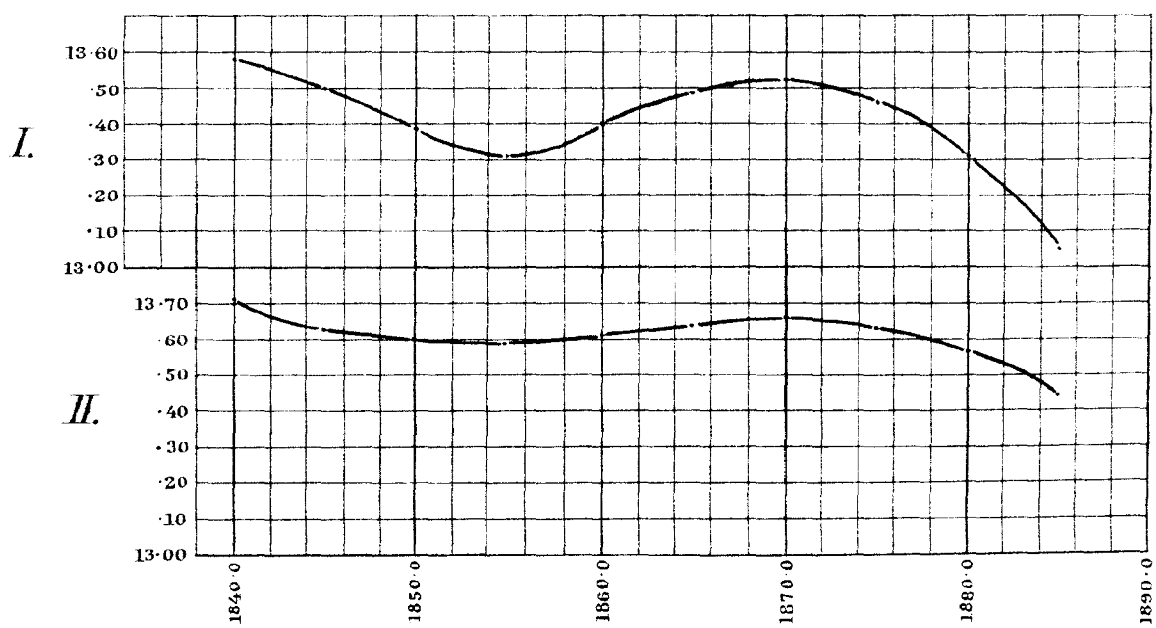
Over the vast regions in British North America north of the boundary of Dakota and extending to the shores of Hudson's Bay, and embracing Lake Winnipeg, observations at York Factory

* Astronomische Nachrichten, No. 954, 1855.

Type-Curves of the secular Variation of the Dip.




Type-Curves of the secular Variation of the total Intensity.



and at the Norway and Cumberland houses make it appear that the dip is now not very different from what it was forty years ago, and probably it has undergone but little change during the interval; in this region the present annual change is supposed very small. Further west, at Fort Chipewyan, Fort Edmonton, and Fort Lesser Slave Lake the annual change may be about $-0'.5$

At Nootka Sound, Vancouver Island, the dip is on the decrease, about $-0'.7$ for the island; further north along the coast at Port Simpson the annual change seems to be about $-1'.5$. It seems certain that in Alaska the dip has been *decreasing* since (about) 1852, with an annual rate varying between $-2'.2$ at Sitka, $-1'.5$ at Unalashka, $-1'.0$ at Port Clarence, near Bering Strait, and $-1'.2$ at Point Barrow. Crossing the strait to Asia the observed dips at Petropavlovsk, Kamchatka, strongly mark out a maximum about 1854, which appears supported by the dips at Port Clarence, as had also been conjectured* for Point Barrow. The Unalashka dips appear to be difficult to reconcile with dips at surrounding stations. Supposed present annual change of dip at Petropavlovsk $-1'.5$, the same as at Unalashka.

With the aid of the preceding results we can roughly trace out the region over which the dip is at present stationary, or where the annual change is zero. This region is marked on the accompanying chart by a shaded band skirting the northern coast of Cuba, passing over lower Louisiana and central Texas, through Mexico, crossing the Gulf of California, following the coast of Southern California, and passing out to sea off San Francisco. Everywhere north of this belt of demarcation the dip is diminishing, south of it increasing in consequence of secular variation, and curves of *equal annual change* in its vicinity would run nearly parallel to it.

The results of the preceding investigation supplied the means by which the observed dips were referred to the common epoch 1885.0, as given in Table I, and, in connection with it, it suffices to state that for each station the latest observation was used, or in case of several late observations each was reduced to the epoch and the mean inserted in the table. A blank indicates insufficient data for reduction and the use of a single decimal that the dip is only roughly known.

It may not be out of place here to offer a few remarks respecting the present position of the pole of the vertical dip. Physicists are not agreed whether this pole is fixed in position or whether it is in motion, and if the latter, what is the direction and velocity of the change. It is now over half a century since Ross made his memorable and successful approach to this point and found it† (June, 1831) in $\varphi = 70^\circ\ 05'.3$, $\lambda = -96^\circ\ 45'.8$, and no serious attempt has since been made either to verify it or to demonstrate by actual observation any change in its position. It seems perhaps more reasonable to suppose its range of displacement to be quite limited than to assign to it, as has been done, a path surrounding the geographical pole, and to be described in several centuries. Observations made on board Her Majesty's ship Brazen in 1813 pointed to approaching verticality in $\varphi = 69^\circ$ and $\lambda = -92^\circ$; and more recently, from the behavior of his compass, Lieutenant Schwatka supposes the pole in 1879 to have shifted to $\lambda = -99^\circ\ 35'$, while he leaves any change in its latitude undecided. If the secular diminution of the dip extends to this northern region the pole would now be found in a higher latitude than that given by Ross, but of this we are not certain. We regard the practical solution of this problem as one of great importance for the theory of terrestrial magnetism, and it is to be regretted that no steps were taken toward its solution in connection with the late international circumpolar explorations.

Science at the present day, however, would not be satisfied with a single line of approach to a dip of $90^\circ$, as in 1831, but the whole region would need exploration since local deflections may vitiate or obscure the recognition of the true place of verticality.

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*Coast and Geodetic Survey Report for 1883, App. No. 13, p. 339.

†Phil. Trans. Roy. Soc., Dec. 1833. According to Gauss' theory the pole is in $\varphi = 73^\circ\ 35'$ $\lambda = -95^\circ\ 39'$.

## PART III.

### SECULAR VARIATION OF THE HORIZONTAL COMPONENT OF THE MAGNETIC FORCE AND OF THE TOTAL INTENSITY IN THE UNITED STATES.

It was not until 1833 that Gauss showed* how the earth's magnetic intensity could be expressed in absolute measure; and in 1836 Weber† constructed the portable magnetometer. Before this time no satisfactory investigation or inquiry could be made respecting either supposed changes or permanency of the magnetic intensity. Although relative intensity measures had been made as early as 1785, no definite results could be arrived at respecting changes in the intensity of the force in consequence of the unknown, gradual and irregular loss of magnetism of the needles employed in these comparisons. The range of time over which our knowledge of the intensity thus practically extends is barely half a century, though some rough guesses may be made as to earlier results.

A first investigation of the secular variations of the horizontal component and of the total force was attempted by me in Appendix No. 22, Coast Survey Report for 1861. In consequence of the scanty material then at command and the large relative size of observing errors as compared with the effect of the secular change, no very decided results were reached. It appeared, however, that in the eastern parts of the United States, during the twenty years then passed, the horizontal component of the force had been *decreasing* at an annual rate of about 0.001 parts of the force, and that in the western part of the country the horizontal force had been *increasing* at an annual rate a trifle greater than that just given. The direct evidence as to a change in total intensity was inconclusive; however, it was certainly very small, whatever its character may have been.

It was soon noticed that in the east the secular diminution in the horizontal component had come to an end about 1855 or 1860 (at Washington and at Toronto), and that after this a steady increase of this component set in which has continued to the present time.

Respecting the secular variation of the total force, we know from the earliest records at Washington and at Toronto that the intensity was subject to a slow decrease. In the preface to his "Diary of a Magnetic Survey of Canada," Sir J. H. Lefroy remarks (in 1883), "The general evidence is conclusive that in middle latitudes on the American continent the intensity of the earth's magnetic force is now decreasing and has been decreasing for about thirty-five years," a conclusion which was supported by recently (1882) published results of the Coast and Geodetic Survey. In the same volume General Lefroy takes occasion to point out a needed correction to the isodynamic lines in Northwest America as laid down from observations by Sir Edward Sabine in Phil. Trans. Roy. Soc., vol. for 1872, and draws attention to the remarkable development of magnetic (total) force on the eastern side of Lake Winnipeg. A resurvey of this region and a first survey of the vast area to the east of it, between the northern shore of Lake Superior and Georgian Bay and the southern and western shores of Hudson's Bay is absolutely indispensable if we desire an adequate knowledge of the region of great intensity and of the locus and amount of its maximum value.

The leading stations selected for the investigation of the secular variation of the horizontal intensity are the same as those given in connection with the discussion of the changes of the dip.

* Intensitas vis magneticæ terrestris ad mensuram absolutam revocata; auctore C. F. Gauss; Gottingæ, 1833.

† Description of a small portable magnetometer for measuring the absolute intensity of terrestrial magnetism, by Professor Weber. Results of the observations made by the magnetic association in the year 1836, Göttingen. See Taylor's Scientific Memoirs, Vol. II, London, 1841.

**TABLE III.**—*Annual values of observed magnetic horizontal force at prominent stations.*

| No. | Locality and observer. | Year and fraction. | Observed horizontal force. |
|---|---|---|---|
| | *Halifax, N. S.* | | |
| 1* | Home. | 1834.4 | 3.229 |
| 2* | Home. | 1837.4 | 3.356 |
| 3* | Keely. | 1847.5 | 3.247 |
| 4 | Maclear and Bromley. | 1873.4 | 3.385 |
| 5 | Baylor. | 1879.7 | 3.452 |
| 6 | Very. | 1881.8 | 3.459 |
| | *Quebec, Canada.* | | |
| 1* | Lefroy. | 1842.7 | 3.023 |
| 2* | Younghusband. | 1845.5 | 3.048 |
| 3 | Schott. | 1859.5 | 2.991 |
| 4 | Baylor. | 1879.7 | 3.104 |
| | *Montreal, Canada.* | | |
| 1 | Lefroy, | 1842.7 | 3.064 |
| 2* | Lefroy and Bache, | 1843.3 }<br>.7 } | { 3.063<br>{ 3.109 |
| 3 | Younghusband. | 1845.5 | 3.012 |
| 4 | Schott. | 1859.5 | 3.111 |
| 5 | Baylor. | 1879.7 | 3.191 |
| | *Cambridge and Boston, Mass.* | | |
| 1 | Loomis. | 1839.7 | 3.658 |
| 2* | Locke and Lefroy. | 1842.5 | 3.650 |
| 3 | Locke. | 1845.4 | 3.618 |
| 4 | Lee (T. J.) and Fauntleroy. | 1846.7 | 3.587 |
| 5 | Schott. | 1855.6 | 3.544 |
| 6 | Friesach. | 1856.5 | 3.542 |
| 7 | Smith (W. P.). | 1859.2 | 3.596 |
| 8 | Scott and Goodfellow. | 1872.8 | 3.675 |
| 9 | Baylor. | 1879.6 | 3.704 |
| | *Providence, R. I.* | | |
| 1 | Bache and Courtenay. | 1835.5 | 3.770 |
| 2 | Loomis. | 1839.7 | 3.726 |
| 3 | Lefroy. | 1842.7 | 3.715 |
| 4 | Schott. | 1855.6 | 3.590 |
| 5 | Sherman. | 1884.5 | 3.769 |
| 6 | Baylor. | 1885.3 | 3.814 |
| | *New Haven, Conn.* | | |
| 1 | Loomis. | 1839.7 | 3.832 |
| 2 | Locke and Lefroy. | 1842.5 | 3.825 |
| 3 | Renwick. | 1844.7 | 3.818 |
| | Fauntleroy. | 1847.8 | 3.667(?) |
| 4 | Ruth. | 1848.6 | 3.772 |
| 5 | Schott. | 1855.6 | 3.690 |
| 6 | Thorpe. | 1878.5 | 3.861 |
| 7 | Sherman. | 1884.5 | 3.870 |
| 8 | Sherman. | 1885.5 | 3.860 |
| | *Albany and Greenbush, N. Y.* | | |
| 1 | Bache and Courtenay. | 1835.5 | 3.578 |
| 2 | Lefroy. | 1842.8 | 3.581 |
| 3 | Locke. | 1844.4 | 3.580 |
| 4 | Schott. | 1855.6 | 3.587 |
| 5 | Friesach. | 1856.7 | 3.575 |
| 6 | Dean. | 1858.4 | 3.586 |
| 6 | Baylor. | 1879.8 | 3.645 |
| | *West Point and Coldspring, N. Y.* | | |
| 1 | Bache and Courtenay. | 1835.5 | 3.866 |
| 2 | Lefroy and Bartlett. | 1842.8 | 3.886 |
| | *West Point and Coldspring, N. Y.—Cont'd.* | | |
| 3 | Bache. | 1843.5 | 4.033 |
| 4 | Schott. | 1855.7 | 3.790 |
| | *New York, N. Y.* | | |
| | Sabine. | 1822.9 | 3.981(?) |
| 1 | Bache and Courtenay. | 1835.0 | 3.973 |
| 2 | Loomis. | 1839.7 | 4.012 |
| 3 | Locke and Bache. | 1841.6 | 4.018 |
| 4 | Lefroy and Locke. | 1842.6 | 4.019 |
| 5 | Locke, Renwick, and Lefroy. | 1844.5 | 4.023 |
| 6 | Locke. | 1846.3 | 4.009 |
| 7 | Schott. | 1855.6 | 3.928 |
| 8 | Scott and Goodfellow. | 1872.8 | 3.982 |
| | *Sandy Hook, N. J.* | | |
| 1 | Renwick. | 1844.6 | 4.077 |
| 2 | Schott. | 1855.6 | 3.917 |
| 3 | Hilgard (T. C.). | 1873.8 | 4.040 |
| 4 | Baylor. | 1879.5 | 4.078 |
| | *Philadelphia, Pa.* | | |
| 1 | Bache and Courtenay. | 1835.5 | 4.195 |
| 2 | Bache. | 1836.7 | 4.159 |
| 3 | Loomis. | 1839.7 | 4.149 |
| 4 | Bache and Locke. | 1841.6 | 4.175 |
| 5 | Bache, Locke, and Lefroy. | 1842.5 | 4.175 |
| 6 | Bache. | 1843.6 | 4.172 |
| 7 | Bache and Locke. | 1844.3 | 4.164 |
| 8 | Bache. | 1845.3 | 4.167 |
| 9 | Locke. | 1846.4 | 4.143 |
| | Schott. | 1855.7 | 4.211(?) |
| 10 | Schott. | 1862.6 | 4.124 |
| 11 | Harkness. | 1865.8 | 4.148 |
| 12 | Scott and Goodfellow. | 1872.8 | 4.161 |
| 13 | Baylor. | 1877.8 | 4.211 |
| 14 | Smith (E.). | 1884.7 | 4.232 |
| | *Baltimore, Md.* | | |
| 1 | Nicolet. | 1832.5 | 4.228 |
| 2 | Bache. | 1840.6 | 4.265 |
| 3 | Locke. | 1841.3 | 4.255 |
| 4 | Lefroy. | 1842.8 | 4.234 |
| 5 | Schott. | 1856.7 | 4.203 |
| 6 | Baylor. | 1877.8 | 4.146 |
| | *Washington and District of Columbia.* | | |
| 1 | Lefroy. | 1842.8 | 4.8316 |
| 2 | Bache. | 1843.0 | 4.320 |
| 3 | Locke. | 1844.3 | 4.289 |
| 4 | Lee (T. J.). | 1845.3 | 4.236 |
| 5 | Dean and Bache. | 1851.5 | 4.233 |
| 6 | Hilgard (J. E.). | 1852.4 | 4.267 |
| 7 | Schott. | 1855.7 | 4.250 |
| 8 | Schott. | 1856.7 | 4.308 |
| 9 | Schott. | 1858.5 | 4.255 |
| 10 | Schott. | 1859.5 | 4.307 |
| 11 | Schott. | 1860.7 | 4.319 |
| 12 | Schott. | 1862.6 | 4.284 |
| 13 | Schott. | 1863.5 | 4.294 |
| 14 | Harkness. | 1866.8 | 4.300 |
| 15 | Schott and Goodfellow. | 1867.5 | 4.321 |
| 16 | Schott. | 1868.5 | 4.334 |

TABLE III.—*Annual values of observed magnetic horizontal force at prominent stations.*—*Continued.*

| No. | Locality and observer. | Year and fraction. | Observed horizontal force. |
|---|---|---|---|
| | *Washington and District of Columbia.—Cont'd.* | | |
| 17 | Schott. | 1869.3 | 4.347 |
| 18 | Schott. | 1870.5 | 4.352 |
| 19 | Schott. | 1871.5 | 4.356 |
| 20 | Schott. | 1872.5 | 4.360 |
| 21 | Schott. | 1873.5 | 4.344 |
| 22 | Schott. | 1874.5 | 4.349 |
| 23 | Schott. | 1875.5 | 4.353 |
| 24 | Schott and Hilgard (F. E.). | 1876.3 | 4.356 |
| 25 | Schott and Braid. | 1877.7 | 4.369 |
| 26 | Schott, Thorpe, and Baylor. | 1878.7 | 4.368 |
| 27 | Eimbeck and Schott. | 1879.5 | 4.370 |
| 28 | Baylor. | 1880.5 | 4.375 |
| 29 | Baylor. | 1881.3 | 4.380 |
| 30 | Eimbeck. | 1882.5 | 4.364 |
| 31 | Schott. | 1883.5 | 4.373 |
| 32 | Maxfield, Eimbeck, and Schott. | 1884.3 | 4.385 |
| 33 | Schott. | 1885.5 | 4.397 |
| | *Pittsburgh and Allegheny, Pa.* | | |
| 1 | Bache. | 1840.6 | 4.049 |
| 2 | Locke. | 1841.2 | 4.059 |
| 3 | Locke. | 1842.3 | 4.056 |
| 4 | Locke. | 1845.3 | 4.034 |
| 5 | Thorpe. | 1878.7 | 4.129 |
| | *Toronto, Canada.* | | |
| 1 | Lefroy. | 1842.8 | 3.535 |
| 2 | Bache. | 1843.6 | 3.537 |
| 3 | Locke. | 1844.5 | 3.540 |
| 4 | Lefroy. | 1845.3 | 3.548 |
| 5 | Lefroy. | 1846.5 | 3.542 |
| 6 | Lefroy. | 1847.5 | 3.538 |
| 7 | Lefroy. | 1848.5 | 3.534 |
| 8 | Lefroy. | 1849.5 | 3.537 |
| 9 | Lefroy. | 1850.5 | 3.532 |
| 10 | Lefroy. | 1851.5 | 3.530 |
| 11 | Lefroy. | 1852.5 | 3.515 |
| 12 | Kingston. | 1855.8 | 3.515 |
| 13 | Kingston. | 1856.5 | 3.505 |
| 14 | Kingston. | 1857.5 | 3.488 |
| 15 | Kingston. | 1858.5 | 3.490 |
| 16 | Kingston. | 1859.5 | 3.481 |
| 17 | Kingston. | 1860.5 | 3.479 |
| 18 | Kingston. | 1861.5 | 3.484 |
| 19 | Kingston. | 1862.5 | 3.485 |
| 20 | Kingston. | 1863.5 | 3.489 |
| 21 | Kingston. | 1864.5 | 3.493 |
| 22 | Kingston. | 1865.5 | 3.493 |
| 23 | Kingston. | 1866.5 | 3.493 |
| 24 | Kingston. | 1867.5 | 3.498 |
| 25 | Kingston. | 1868.5 | 3.498 |
| 26 | Kingston. | 1869.5 | 3.499 |
| 27 | Kingston. | 1870.5 | 3.498 |
| 28 | Kingston. | 1871.5 | 3.500 |
| 29 | Carpmael. | 1885.3 | 3.591 |
| | *Cleveland, Ohio.* | | |
| 1 | Younghusband. | 1842.8 | 3.981 |
| 2 | Locke. | 1843.6 | 4.005 |
| 3 | Smith (W. P.). | 1859.5 | 3.956 |
| 4 | Goodfellow. | 1871.8 | 4.000 |
| 5 | Lee (A. N.). | 1872.5 | 4.017 |
| 6 | Lee (A. N.). | 1873.5 | 3.996 |
| 7 | Baylor. | 1880.5 | 3.996 |
| | *Detroit, Mich.* | | |
| 1 | Younghusband. | 1842.8 | 3.930 |
| 2 | Locke. | 1843.4 | 3.892 |
| 3 | Lefroy. | 1845.5 | 3.863 |
| 4 | Smith (W. P.). | 1859.3 | 3.838 |
| 5 | Smith (W. P.). | 1860.4 | 3.865 |
| 6 | Lee (A. N.). | 1872.4 | 3.881 |
| 7 | Lee (A. N.). | 1873.4 | 3.880 |
| 8 | Bailey. | 1876.4 | 3.898 |
| | *Cincinnati, Ohio.* | | |
| 1 | Locke. | 1844.4 | 4.548 |
| 2 | Locke. | 1845.3 | 4.548 |
| 3 | Lefroy. | 1849.4 | 4.527 |
| 4 | Baylor. | 1880.9 | 4.488 |
| | *Madison, Wis.* | | |
| 1 | Locke. | 1839.8 | 3.878 |
| 2 | Hilgard (F. E.). | 1876.8 | 3.891 |
| 3 | Braid. | 1877.7 | 3.913 |
| 4 | Suess and Baylor. | 1878.8 | 3.896 |
| 5 | Mason. | 1879.7 | 3.908 |
| 6 | Mason. | 1880.7 | 3.903 |
| 7 | Suess. | 1881.9 | 3.898 |
| | *Saint Louis, Mo.* | | |
| 1 | Nicollet. | 1836.0 | 4.814 |
| 2 | Locke. | 1839.7 | 4.748 |
| | Friesach. | 1856.8 | 4.925 (?) |
| 3 | Hilgard (T. C.). | 1872.5 | 4.629 |
| | Nipher. | 1878.6 | 4.586 (?) |
| 4 | Nipher. | 1879.7 | 4.673 |
| | *Nassau, New Providence Island.* | | |
| 1 | Ackley. | 1879.1 | 6.503 |
| | *Havana, Cuba.* | | |
| 1 | Humboldt. | 1801.0 | 6.100 (?) |
| 2 | Sabine. | 1822.5 | 6.970 |
| 3 | Friesach. | 1857.1 | 6.921 |
| 4 | Ackley. | 1879.2 | 6.847 |
| | *Saint Thomas, West Indies.* | | |
| 1 | Friesach. | 1857.1 | 6.723 |
| 2 | Harkness. | 1865.9 | 6.758 |
| | *Panama, United States of Colombia.* | | |
| 1 | Belcher. | 1837.5 | 7.743 |
| 2 | Haig. | 1858.3 | 7.654 |
| 3 | Harkness. | 1866.4 | 7.614 |
| | *Acapulco, Mexico.* | | |
| 1 | Belcher. | 1838.5 | 7.910 |
| 2 | Harkness. | 1866.4 | 7.740 |
| 3 | Nichols. | 1880.9 | 7.518 |
| | *Mexico, Mexico.* | | |
| 1 | Humboldt. | 1803.9 | 6.690 (?) |
| 2 | Sonntag and Mueller. | 1857.9 | 7.576 |
| 3 | Keyes. | 1879.8 | 7.480 |
| | *San Blas, Mexico.* | | |
| 1 | Belcher. | 1838.5 | 7.590 |
| 2 | Belcher. | 1339.5 | 7.421 |
| 3 | Nichols. | 1880.9 | 7.204 |

TABLE III.—*Annual values of observed magnetic horizontal force at prominent stations.*—*Continued.*

| No. | Locality and observer. | Year and fraction. | Observed horizontal force. |
|---|---|---|---|
| | *Magdalena Bay, Lower California.* | | |
| 1 | Belcher. | 1839.5 | 7.160 |
| 2 | Harkness. | 1866.4 | 7.176 |
| 3 | Eimbeck. | 1873.2 | 6.926 |
| 4 | Nichols. | 1881.1 | 7.032 |
| | *San Diego, Cal.* | | |
| 1 | Belcher. | 1839.5 | 6.142 |
| 2 | Trowbridge. | 1853.8 | 6.271 |
| 3 | Harkness. | 1866.5 | 6.261 |
| 4 | Throckmorton. | 1872.9 | 6.159 |
| 5 | Nichols. | 1881.3 | 6.104 |
| | *Los Angeles, Cal.* | | |
| 1 | Baker. | 1882.8 | 5.913 |
| 2 | Baker. | 1883.5 | 5.919 |
| 3 | Baker and Terry. | 1884.5 | 5.915 |
| 4 | Terry. | 1885.3 | 5.911 |
| | *Santa Barbara, Cal.* | | |
| 1 | Douglas. | 1831.4 | 5.861 |
| 2 | Belcher. | 1839.5 | 5.925 |
| 3 | Davidson and Throckmorton. | 1869.9 | 5.967 |
| 4 | Nichols. | 1881.3 | 5.871 |
| | *Monterey, Cal.* | | |
| 1 | Douglas. | 1831.0 | 5.629 |
| 2 | Belcher. | 1839.5 | 5.666 |
| 3 | Trowbridge. | 1854.4 | 5.802 |
| 4 | Throckmorton. | 1873.7 | 5.696 |
| 5 | Nichols. | 1881.3 | 5.663 |
| | *San Francisco, Cal.* | | |
| 1 | Douglas. | 1831.1 | 5.495 |
| 2 | Belcher. | 1839.5 | 5.524 |
| 3 | Friesach. | 1858.4 | 5.576 |
| 4 | Harkness. | 1866.5 | 5.643 |
| 5 | Davidson, Throckmorton, and Eimbeck. | 1873.9 | 5.543 |
| 6 | Dall, Baker, and Nichols. | 1880.7 | 5.514 |
| 7 | Eimbeck, Marr, Nichols, and Lawson. | 1881.5 | 5.523 |
| 8 | Marr. | 1883.4 | 5.481 |
| 9 | Davidson and Marr. | 1884.7 | 5.507 |
| | *Cape Disappointment, Wash.* | | |
| 1 | Douglas. | 1830.8 | 4.436 |
| 2 | Belcher. | 1839.5 | 4.394 |
| 3 | Eimbeck. | 1873.8 | 4.537 |
| 4 | Nichols. | 1881.8 | 4.482 |
| | *Fort Vancouver, Wash.* | | |
| 1 | Douglas. | 1830.9 | 4.442 |
| 2 | Belcher. | 1839.5 | 4.475 |
| 3 | Haig. | 1860.3 | 4.618 |
| 4 | Lawson. | 1881.8 | 4.547 |
| | *Nootka Sound, Vancouver Island.* | | |
| 1 | Nichols. | 1881.7 | 4.083 |
| | *York Factory, British N. A.* | | |
| 1 | Lefroy. | 1843.6 | 1.505 |
| 2 | Klotz. | 1884.7 | 1.508 |
| | *Norway House, British N. A.* | | |
| 1 | Lefroy. | 1844.1 | 2.175 |
| 2 | Klotz. | 1884.6 | 2.148 |
| | *Cumberland House, British N. A.* | | |
| 1 | Lefroy. | 1844.1 | 2.357 |
| 2 | Klotz. | 1884.5 | 2.345 |
| | *Sitka, Alaska.* | | |
| 1 | Lütke. | 1827.5 | 3.197 |
| 2 | Erman. | 1829.9 | 3.197 |
| 3 | Belcher. | 1839.5 | 3.207 |
| 4 | Dall and Baker. | 1880.4 | 3.310 |
| 5 | Nichols. | 1881.7 | 3.293 |
| | *Unalashka, Alaska.* | | |
| 1 | Lütke. | 1827.6 | 4.468 |
| 2 | Lütke. | 1829.5 | 4.584 |
| 3 | Dall and Baker. | 1880.7 | 4.456 |
| 4 | Marr. | 1883.7 | 4.386 |
| | *Port Clarence and Grantley Bay, Alaska.* | | |
| 1 | Wijkander. | 1879.5 | 3.028 |
| 2 | Dall and Baker. | 1880.7 | 3.022 |
| | *Petropavlovsk, Kamchatka.* | | |
| 1 | Erman. | 1829.8 | 4.964 |
| 2 | Du Petit Thouars. | 1837.7 | 4.856 |

To ascertain in general the characteristic features of the change in the horizontal component, the observed values of H were plotted for each station. It then became apparent that, perhaps with the exception of a few stations, the observed data were insufficient to trace out the law with distinctness at any one station, but that *collectively* fairly satisfactory results could be had. Three distinct types of change could be recognized, and the stations exhibiting like types were grouped and their results united into a mean, as shown in the following table. The values of H, as tabulated for every fifth year, are the result of a free hand curve drawn among the dots representing the observed values, in order that their accidental errors may be eliminated as far as possible.

The observations at the three Canadian stations, Halifax, Quebec and Montreal, were found too irregular to be combined; they concur, however, in indicating *increasing* force since 1860 or some earlier date. The stations in the West Indies, Central America, and Mexico likewise could not be treated in the manner proposed, from insufficiency of observations, but they clearly indicate *decreasing* force from a date anterior to that just mentioned. This matter will be referred to again in connection with the annual change. In Alaska, likewise, the horizontal component is apparently at present decreasing.

*Type-curve No. I, showing secular variation of the horizontal intensity (H) for the northeastern part of the United States (see diagram).*

| Stations. | (Jan. 1), 1830. | 1835. | 1840. | 1845. | 1850. | 1855. | 1860. | 1865. | 1870. | 1875. | 1880. | (Jan. 1), 1885. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cambridge. | ---- | ---- | 3.66 | 3.61 | 3.565 | 3.555 | 3.59 | 3.62 | 3.66 | 3.685 | 3.70 | 3.715 |
| New Haven. | ---- | ---- | 3.83 | 3.805 | 3.75 | 3.70 | 3.72 | 3.76 | 3.80 | 3.835 | 3.86 | 3.87 |
| New York. | ---- | ---- | 4.02 | 4.01 | 3.97 | 3.93 | 3.94 | 3.955 | 3.97 | 3.99 | 4.01 | 4.03 |
| Sandy Hook. | ---- | ---- | 4.09 | 4.06 | 3.99 | 3.925 | 3.94 | 3.98 | 4.01 | 4.04 | 4.07 | 4.10 |
| Albany. | ---- | ---- | 3.60 | 3.58 | 3.58 | 3.58 | 3.585 | 3.60 | 3.615 | 3.63 | 3.645 | 3.66 |
| Average. | ---- | ---- | 3.840 | 3.813 | 3.771 | 3.738 | 3.755 | 3.783 | 3.811 | 3.836 | 3.857 | 3.875 |

*Type-curve No. II, showing secular variation of the horizontal intensity (H) for the eastern part of the United States (see diagram).*

| Stations. | (Jan. 1), 1830. | 1835. | 1840. | 1845. | 1850. | 1855. | 1860. | 1865. | 1870. | 1875. | 1880. | (Jan. 1), 1885. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Philadelphia. | ---- | ---- | 4.18 | 4.15 | 4.14 | 4.13 | 4.13 | 4.14 | 4.16 | 4.19 | 4.22 | 4.23 |
| Baltimore. | ---- | ---- | 4.25 | 4.23 | 4.21 | 4.20 | 4.21 | 4.21 | 4.22 | 4.24 | 4.25 | 4.27 |
| Washington. | ---- | ---- | 4.285 | 4.265 | 4.250 | 4.265 | 4.290 | 4.315 | 4.335 | 4.355 | 4.370 | 4.395 |
| Toronto. | ---- | ---- | 3.565 | 3.545 | 3.535 | 3.510 | 3.480 | 3.495 | 3.500 | 3.52 | 3.56 | 3.589 |
| Cleveland. | ---- | ---- | 4.00 | 3.985 | 3.975 | 3.965 | 3.965 | 3.975 | 3.985 | 3.995 | 4.01 | 4.03 |
| Detroit. | ---- | ---- | 3.91 | 3.895 | 3.865 | 3.850 | 3.855 | 3.86 | 3.87 | 3.89 | 3.905 | 3.92 |
| Average. | ---- | ---- | 4.032 | 4.012 | 3.996 | 3.987 | 3.988 | 3.998 | 4.012 | 4.032 | 4.053 | 4.072 |

*Type-curve No. III, showing secular variation of the horizontal intensity (H) for the western coast of the United States (see diagram).*

| Stations. | (Jan. 1), 1830. | 1835. | 1840. | 1845. | 1850. | 1855. | 1860. | 1865. | 1870. | 1875. | 1880. | (Jan. 1), 1885. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| San Diego. | 6.12 | 6.14 | 6.16 | 6.195 | 6.22 | 6.25 | 6.265 | 6.245 | 6.20 | 6.15 | 6.105 | 6.07 |
| Santa Barbara. | 5.87 | 5.89 | 5.92 | 5.935 | 5.945 | 5.955 | 5.96 | 5.95 | 5.94 | 5.92 | 5.885 | 5.84 |
| Monterey. | 5.63 | 5.645 | 5.675 | 5.71 | 5.75 | 5.77 | 5.76 | 5.75 | 5.72 | 5.69 | 5.665 | 5.65 |
| San Francisco. | 5.495 | 5.51 | 5.52 | 5.54 | 5.56 | 5.575 | 5.59 | 5.59 | 5.58 | 5.545 | 5.515 | 5.49 |
| Fort Vancouver. | 4.44 | 4.46 | 4.48 | 4.515 | 4.55 | 4.565 | 4.585 | 4.585 | 4.575 | 4.56 | 4.54 | 4.53 |
| Average. | 5.511 | 5.529 | 5.551 | 5.579 | 5.605 | 5.623 | 5.632 | 5.624 | 5.603 | 5.573 | 5.542 | 5.516 |

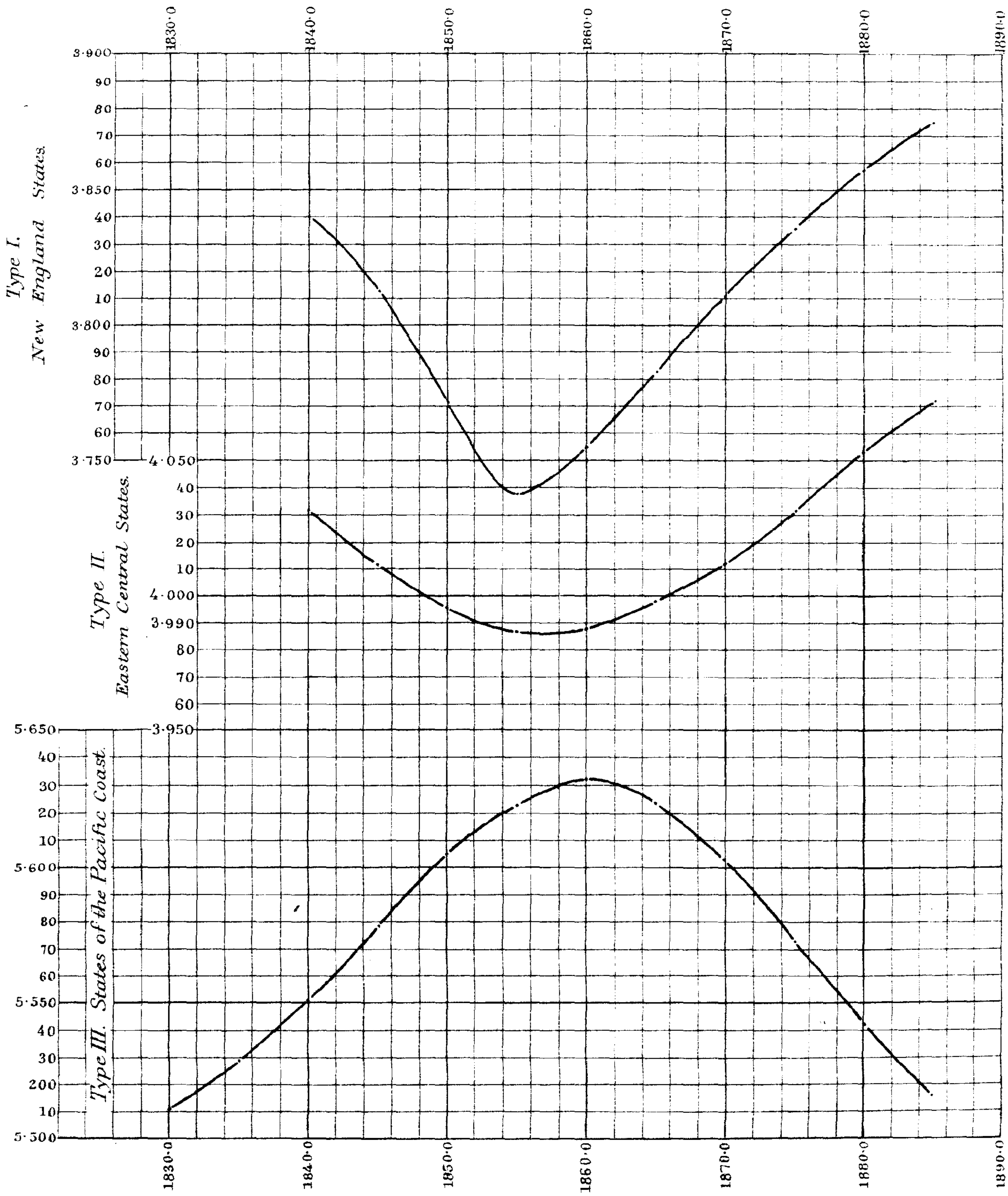
The annual change $a=\frac{d\,\mathrm{H}}{d\,t}$ can be made out for a number of stations, and is found to have been sufficiently uniform for some years past to be deduced directly from recent observations; the average annual rate of change thus made out results from observations made subsequent to the time of the last maximum or minimum.

Let $a=$ recent annual change of the horizontal force, expressed in absolute measure (English units), + when the force is increasing, — when decreasing,

and $a_{,}=$ recent annual change of the horizontal force when expressed in parts of H; hence $a_{,}=\frac{a}{\mathrm{H}_m}$

where $\mathrm{H}_m=$ mean value of H during the interval $t_{,,}-t_{,}$.

## Type-Curves of the secular Variation of the horizontal Intensity.



We have the following values of $a$ and $a_1$, together with their mean values for certain geographical groups:

| Name of station. | Between epochs $t_1$ and $t_{11}$. | | Annual change $a$. | Annual change $a_1$. |
|---|---|---|---|---|
| Halifax, N. S. | 1848(?) | 1882 | +.0062 | +.0019 |
| Quebec, Can. | 1860 | 1880 | +.0056 | +.0018 |
| Montreal, Can. | 1860 | 1880 | +.0040 | +.0013 |
| Mean, group 1. | 1856 | 1881 | +.0053 | +.0017 |
| Cambridge, Mass. | 1856 | 1880 | +.0068 | +.0019 |
| Toronto, Can. | 1871 | 1885 | +.0065 | +.0018 |
| New Haven, Conn. | 1855 | 1885 | +.0058 | +.0015 |
| Albany, N. Y. | 1857 | 1880 | +.0030 | +.0009 |
| New York, N. Y. | 1856 | 1873 | +.0032 | +.0008 |
| Sandy Hook, N. J. | 1856 | 1880 | +.0067 | +.0017 |
| Philadelphia, Pa. | 1863 | 1885 | +.0049 | +.0012 |
| Mean, group 2. | 1859 | 1881 | +.0053 | +.0014 |
| Baltimore, Md. | 1857 | 1878 | +.0020 | +.0005 |
| Washington, D. C. | 1856 | 1885 | +.0041 | +.0009 |
| Cleveland, Ohio. | 1860 | 1881 | +.0020 | +.0005 |
| Detroit, Mich. | 1860 | 1876 | +.0029 | +.0007 |
| Mean, group 3. | 1858 | 1880 | +.0028 | +.0007 |
| Havana, Cuba. | 1857 | 1879 | −.0034 | −.0005 |
| Panama, U. S. of Col. | 1858 | 1866 | −.0050 | −.0007 |
| Acapulco, Mex. | 1866 | 1881 | −.0089 | −.0012 |
| Mexico, Mex. | 1858 | 1880 | −.0044 | −.0006 |
| San Blas, Mex. | 1840(?) | 1881 | −.0053 | −.0007 |
| Mean, group 4. | 1856 | 1877 | −.0054 | −.0007 |
| Magdalena Bay, L. C. | 1866 | 1881 | −.0096 | −.0014 |
| San Diego, Cal. | 1866 | 1881 | −.0105 | −.0017 |
| Santa Barbara, Cal. | 1870 | 1881 | −.0084 | −.0014 |
| Monterey, Cal. | 1874 | 1881 | −.0043 | −.0008 |
| San Francisco, Cal. | 1874 | 1884 | −.0048 | −.0006 |
| Cape Disappointment, W. T. | 1874 | 1882 | −.0069 | −.0015 |
| Mean, group 5. | 1874 | 1882 | −.0070 | −.0012 |

For British North America our data are insufficient to give any definite information of the character of the change during the last forty years, and apparently the present horizontal intensities have again nearly approached the values they had at the earlier epoch. The same uncertainty prevails for the Territory of Alaska respecting the past as well as the present changes in the values of H.

Analogous to the region of stationary dip we also recognize, but much less distinctly, a broad belt stretching across the country in a northwesterly and southeasterly direction, in which the horizontal component is at present stationary, or where the annual change of the horizontal force is nil. This region passes, roughly speaking, through western Montana, Wyoming, Nebraska, Missouri, Tennessee, Georgia and Florida, possibly with a width of two hundred statute miles or more. This broad belt, therefore, does not coincide in position with a similar belt of unchangeable dip at the present time. To the northward and eastward of this belt of demarkation, as shown on the accompanying map, the horizontal component is in a state of increase, to the southward and westward of it in a state of decrease. In either case the annual change, as also in the case of the annual change of the dip, becomes greater the farther a place is distant from the respective marked regions of constancy.

### SECULAR VARIATION OF THE TOTAL INTENSITY OF THE MAGNETIC FORCE.

The data for the investigation of the variation in the total intensity are those already given for the dip and horizontal force, and they need only combination to yield the results desired.

The following table contains the values of the intensity F, as computed from the corresponding values of H and $\theta$ for types I and II, the data for other types being either incomplete or wanting. F is expressed in British units.

| Stations. | (Jan. 1), 1830. | 1835. | 1840. | 1845. | 1850. | 1855. | 1860. | 1865. | 1870. | 1875. | 1880. | (Jan. 1), 1885. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cambridge. | ---- | ---- | 13.48 | 13.33 | 13.21 | 13.22 | 13.37 | 13.45 | 13.49 | 13.39 | 13.14 | 12.79 |
| New Haven. | ---- | ---- | 13.47 | 13.40 | 13.25 | 13.11 | 13.20 | 13.33 | 13.41 | 13.41 | 13.29 | 13.05 |
| New York. | ---- | ---- | 13.56 | 13.51 | 13.39 | 13.27 | 13.32 | 13.36 | 13.36 | 13.31 | 13.19 | 12.99 |
| Sandy Hook. | ---- | ---- | 13.70 | 13.59 | 13.36 | 13.17 | 13.23 | 13.35 | 13.40 | 13.39 | 13.30 | 13.13 |
| Albany. | ---- | ---- | 13.68 | 13.65 | 13.72 | 13.80 | 13.87 | 13.93 | 13.92 | 13.82 | 13.61 | 13.27 |
| Average, type I. | ---- | ---- | 13.58 | 13.50 | 13.39 | 13.31 | 13.40 | 13.48 | 13.52 | 13.46 | 13.31 | 13.05 |
| Philadelphia. | ---- | ---- | 13.52 | 13.44 | 13.45 | 13.47 | 13.51 | 13.55 | 13.58 | 13.57 | 13.49 | 13.25 |
| Baltimore. | ---- | ---- | 13.56 | 13.45 | 13.38 | 13.37 | 13.44 | 13.46 | 13.48 | 13.48 | 13.38 | 13.22 |
| Washington. | ---- | ---- | 13.43 | 13.36 | 13.31 | 13.34 | 13.39 | 13.42 | 13.42 | 13.38 | 13.29 | 13.20 |
| Toronto. | ---- | ---- | 14.03 | 13.93 | 13.95 | 13.91 | 13.82 | 13.82 | 13.77 | 13.78 | 13.78 | 13.76 |
| Cleveland. | ---- | ---- | 13.85 | 13.78 | 13.76 | 13.75 | 13.78 | 13.83 | 13.84 | 13.81 | 13.74 | 13.61 |
| Detroit. | ---- | ---- | 13.85 | 13.80 | 13.71 | 13.68 | 13.72 | 13.75 | 13.76 | 13.78 | 13.73 | 13.62 |
| Average, type II. | ---- | ---- | 13.71 | 13.63 | 13.59 | 13.59 | 13.61 | 13.64 | 13.64 | 13.63 | 13.57 | 13.44 |

The two type-curves are shown in a preceding illustration in connection with the curves for the dip, and their comparison indicates the preponderating influence of the change of the latter over the change in the horizontal force.

At any place where H, $dH$, $\theta$, and $d\theta$ are known, the annual change in F can be computed by $dF = \sec \theta dH + F \tan \theta d\theta$, in absolute measure, or by $\frac{dF}{F} = \frac{dH}{H} + \tan \theta d\theta$ expressed in parts of the force; similarly the annual change $dV$ of V may be computed by $dV = H \sec^2 \theta d\theta + \tan \theta dH$ and $\frac{dV}{V} = \frac{d\theta}{\sin \theta \cos \theta} + \frac{dH}{H}$, when expressed in parts of the vertical component.

### SECULAR VARIATION OF THE DIRECTION OF A FREELY SUSPENDED MAGNETIC NEEDLE.

Quite an instructive diagram may be constructed by combining the secular variations of the declination and of the dip so as to show the actual secular motion of the direction of a magnetic needle when *freely* suspended.*

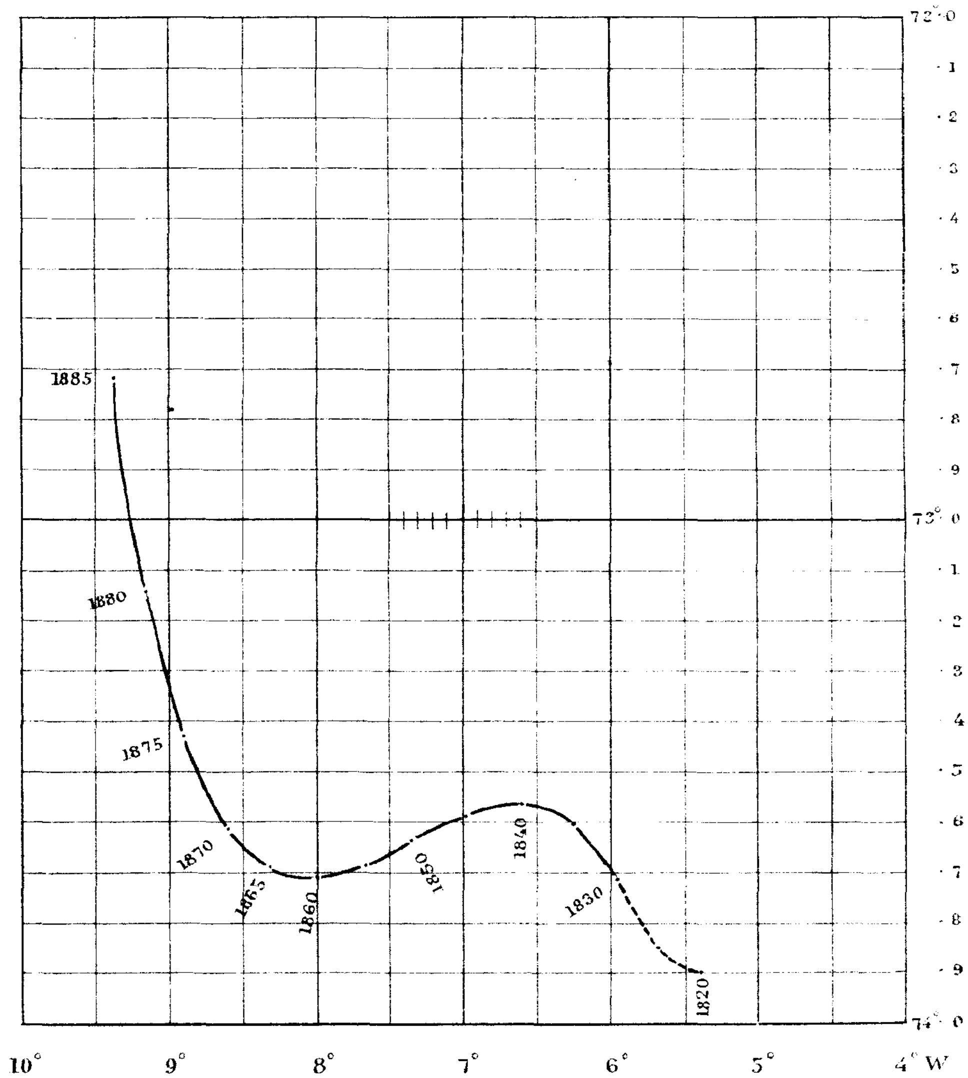
Conceive a sphere described with any convenient radius about the center of gravity of the needle, and suppose that portion of its *inner* surface viewed (from the center) toward which the north end of the needle may be pointing. Producing the direction of the north end of the needle, as observed at any given epoch, it will intersect the sphere in a given point, and a series of such points will be had if this be repeated for a number of epochs. A curve freely drawn through these consecutive points will then represent the actual secular motion in the direction of the needle, and may be projected on a plane, tangent to the sphere at a point near the middle of the region.

For our illustration we select the group of northeastern stations and designated as type I, the average geographical position for which corresponds approximately to central Connecticut. The dips for each fifth year have already been given; the corresponding declinations were taken from

* A similar diagram was recently employed by Dr. W. Schaper to exhibit the complete *hourly* variations of the needle at Lübeck for December 23, 1884.

Secular Variation in the Direction of a freely suspended magnetic Needle for the Period 1820 to 1885.

(New England States.)



the Coast and Geodetic Survey Report for 1882, Appendix No. 12, either directly from the table for each tenth year or by computation (using the formulæ given on page 258). The values are given below, the plus sign being omitted (denoting west declination), as applying to all:

| Stations. | (Jan. 1), 1825. | 1830. | 1835. | 1840. | 1845. | 1850. | 1855. | 1860. | 1865. | 1870. | 1875. | 1880. | (Jan. 1), 1885. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| Cambridge. | 8. 32 | 8. 64 | 8. 98 | 9. 33 | 9. 69 | 10. 03 | 10. 36 | 10. 67 | 10. 96 | 11. 21 | 11. 44 | 11. 63 | 11. 78 |
| New Haven. | 5. 17 | 5. 39 | 5. 65 | 5. 95 | 6. 27 | 6. 61 | 6. 97 | 7. 35 | 7. 72 | 8. 10 | 8. 47 | 8. 84 | 9. 19 |
| New York. | 4. 63 | 4. 88 | 5. 20 | 5. 56 | 5. 94 | 6. 31 | 6. 64 | 6. 93 | 7. 18 | 7. 40 | 7. 60 | 7. 81 | 8. 03 |
| Sandy Hook. | 4. 26 | 4. 51 | 4. 83 | 5. 19 | 5. 57 | 5. 94 | 6. 27 | 6. 56 | 6. 81 | 7. 03 | 7. 23 | 7. 44 | 7. 66 |
| Albany. | 6. 06 | 6. 35 | 6. 66 | 7. 00 | 7. 36 | 7. 74 | 8. 11 | 8. 49 | 8. 86 | 9. 23 | 9. 57 | 9. 90 | 10. 19 |
| Average, type I. | 5. 69 | 5. 95 | 6. 26 | 6. 61 | 6. 96 | 7. 33 | 7. 67 | 8. 00 | 8. 31 | 8. 59 | 8. 86 | 9. 12 | 9. 37 |

Suppose radius of sphere = 4 m., one degree of a great circle would have the length $\frac{4}{57.3}$ nearly, or 6.98 cm., and one degree of a parallel for average dip of 73° would equal 6.98 cos 73°, or 2.04 cm. The diagram is constructed accordingly;* the degrees marked on the right-hand margin are those of the dip, *diminishing* upwards; the degrees marked at the bottom are those of the declination, *increasing* to the *left* or *westward*.

Plotting the typical values of dip and declination for every fifth year between 1830 and 1885, and uniting the points so obtained by a free-hand curve, we have the representation of the secular motion of a freely suspended needle, as shown in the accompanying diagram. The dotted part between 1820 and 1830 is doubtful, only one of the coördinates being known with certainty. In its further extension into past time the curve is known to be a tangent to the vertical line of 4°.9 in or about the year 1794 (see Table III of Appendix 12, Report for 1882), and it is here where we regret most the total absence of information respecting the state of the dip, and which debars us from even conjecturing the course of the curve during the past century, though it lies wholly to the westward of the vertical touched in 1794.

The secular variation in the total intensity might also be indicated in the diagram by variation in the thickness of the curve. The change, however, is of a very simple nature, and it suffices to state that since about 1870 the magnetic force has been rapidly declining in intensity.

CONSTRUCTION OF ISOMAGNETIC MAPS OF THE UNITED STATES, SHOWING THE DISTRIBUTION OF THE DIP AND OF THE HORIZONTAL COMPONENT AND TOTAL VALUE OF THE EARTH'S MAGNETIC INTENSITY, FOR THE EPOCH JANUARY 1, 1885.

It is not our purpose to review here in particular any one of the isomagnetic maps that have been constructed from time to time since the production of the first *isoclinic* map by Wilke, in 1768, and the first *isodynamic* map by Humboldt, which was based upon his American observations, made between 1799 and 1804; but we shall briefly refer to some maps more specially related to the United States or covering parts of its territory.

We need but mention, as claiming now but little attention in consequence of their necessary imperfections, the isoclinic maps published by Hansteen in the first quarter of the present century. That for the epoch 1600 is based on the dip observations of Hudson and Baffin; that for 1700 on observations of Cunningham, Feuillée, La Caille, and Ekeberg; that for 1780 on observations by Cook and La Perouse. Gauss, in his great work on the General Theory of Terrestrial Magnetism, obtains his data for the inclination mainly from Horner's map (date about 1827), and for the intensities (total) from the admirable map published by Major E. Sabine (Report of the Seventh Meeting of the British Association for the Advancement of Science, Vol. VI, London, 1838). No strict reduction to a fixed epoch was then practicable, and the results group themselves, on the average, near or before the year 1830, as a rough epoch. The maps of the values of the inclination and of the horizontal force, computed according to the theory of Gauss, are contained in Taylor's Scientific Memoirs, Vol. II, Part VII, London, 1841.

*A gnomonic or central projection might be used with advantage, but for the present the simpler construction answers as well.

In the Philosophical Transactions of the Royal Society for 1840 Major Sabine gives two charts, entitled "Magnetic Isoclinal Lines in the Atlantic, 1837," and "Magnetic Isodynamic Lines in the Atlantic, 1837." The first of these special charts only reaches the eastern border of the United States. In Silliman's Journal, 1838, Art. III, Prof. E. Loomis laid down the lines of equal dip for every 5° for the eastern part of the United States, but disclaims any great precision for them; again, in Silliman's Journal, Vol. XXXIX, 1840, he gives a map of equal dip for the epoch 1840, with the remark that the lines in the northeastern part are fairly accurate, but those in the southeastern part in a measure conjectural.

Appendix No. 28 of the Coast Survey Report for 1856, by Superintendent A. D. Bache and Assistant J. E. Hilgard, is accompanied by a small map showing for the epoch 1850 the distribution of the inclination and of the horizontal intensity along a narrow strip of our Atlantic, Gulf, and Pacific coasts, and along the Mexican boundary. In the Coast Survey Report for 1862 Superintendent A. D. Bache gives a map of Pennsylvania, showing for the epoch 1842 the distribution of the dip, the horizontal and total intensity for that State.

The contributions to terrestrial magnetism, Nos. XIII and XIV, by General Sir E. Sabine, in the Phil. Trans. Roy. Soc. for 1872 and 1875, contain most valuable maps, forming part of the representation of the magnetic condition of the earth's surface about the epoch 1840–'45. Plate XLIX in the volume for 1872 shows the distribution of the inclination on a circumpolar map down to north latitude 35°, and Plate L the distribution of the total intensity within the same limits. To complete the work for the northern hemisphere, Plates Nos. 27 and 28, Phil. Trans. of 1875, exhibit the distribution of these same elements for the zone between north latitude 40° and the equator. On these maps we find marked, besides the curves of definite values, the position and value for each individual station.

The latest published charts are those by General Sir J. H. Lefroy in his "Diary of a Magnetic Survey in Canada, &c.," London, 1883. These are on a comparatively large scale, so as to permit, in regions where the magnetic stations were numerons, the representation of the larger local deflections. The curves, consequently, do not show that symmetry or uniformity which forms so familiar a feature of the older charts. There are four, all for the epoch 1844; the values of the inclination, and of the total intensity are given for each station, with curves for intervals of one degree and of 0.5 (English) units, respectively. Plate V includes the region of our northwestern boundary from Lake Superior to the Pacific, where it extends down to the central latitude of Oregon; Plate VI comprises all that part of the United States lying between the States of Maine, North Carolina, Missouri, and Minnesota.

Notwithstanding the fact that dip observations date back fully three centuries, and relative intensity observations just one century, and that we have absolute measure for a little more than half that time, we cannot utilize all the material here collected for the purpose of giving greater completeness or greater precision to our charts, but must content ourselves with using only those observations which are of *recent date*. Otherwise there would be great liability to error in consequence of defective reduction to epoch, our present knowledge of the secular variation being inadequate in range and amount. In regions where we have imperfect or no knowledge of the secular change of either element the fact is indicated in their graphical representation by dotted lines, and in the tabular statement it is indicated by the result being given with one place of decimals less than the usual number. Numbers within parentheses were not used at all, these results having been recognized as defective. The observations in the Territory of Alaska are yet too scanty for satisfactory charting. For the plotting of the positions and observed values of the stations on the three maps I am indebted to Mr. A. Ziwet, of the Computing Division.

Upon the whole, the representation of the dip for the epoch 1885 is far more satisfactory than the representation of the horizontal intensity for the same epoch, and it appeared plain enough that the cause was to be found in defective determination of the instrumental constants required for the latter measure.

In conclusion, we regard the compilation and discussion of the magnetic dips and intensities herewith presented as of more permanent value than the mere reduction to epoch and their charting, which latter operations may be much better performed after the lapse of some years, when the law of secular variation shall have become better understood.

# APPENDIX No. 7.

## COLLECTION OF SOME MAGNETIC VARIATIONS OFF THE COASTS OF CALIFORNIA AND MEXICO, OBSERVED BY SPANISH NAVIGATORS IN THE LAST QUARTER OF THE EIGHTEENTH CENTURY.

Communicated by GEORGE DAVIDSON, Assistant.

This paper contains excerpts from the logs of certain Spanish vessels which sailed from the ports of San Lucas, Lower California, and San Blas, Mexico, in the years 1774 to 1790, giving the magnetic variation at different parts of the voyage.

The notes are from an English manuscript translation of a Spanish manuscript copy of the original documents. There is no mention, as far as seen, of the way in which the variations were obtained, nor any explanation of the asterisk (*) which distinguishes some of them.

These documents in Spanish are copies of the manuscript documents in the State Department at Washington, and were furnished to me some years since. Those in the State Department were copied from the archives at Madrid pending the question of the northwest boundary of the United States.

The tabulation is made only on those dates when the variation appears in the proper column, and I suspect that some of the given variations are interpolated, unless we suppose that they as regularly observed the sun for azimuth as for position. I think it probable that the star (*) to an observation means that the azimuth was determined from observations on a star instead of the sun.

The notes as to seeing land, &c., will in a rough way check the longitudes, which are crude at the very best; in one case they found themselves 9° in error, but the landfall checks it. I am indebted to Assistant C. A. Schott for filling in the column headed "Longitude west from Greenwich." He assumed for the longitude of San Lucas — 109° 54′, and for the longitude of San Blas — 105° 17′, with a probable uncertainty of ± 0′.5, and the figures given are those resulting from the addition or subtraction (as the case may be) of the differential values of the preceding column to or from one or the other of these absolute longitudes.

GEORGE DAVIDSON.

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### *Voyage of frigate Santiago for discovery of north coast of California.*

[Commander Don Juan Berez, lieutenant of the Royal Navy.]

| Date. | Lat. north. | Long. west of San Lucas. | Long. west from Greenwich. | Variation north-east. | Remarks. |
|---|---|---|---|---|---|
| 1774. | ° ′ | ° ′ | ° ′ | ° ′ | Left San Blas 25th. |
| Jan. 31 | 20 45 | 3 54 | 113 48 | 5 00 | [Off Lower California—Sch.] |
| Feb. 1 | 20 29 | 3 32 | 113 26 | 5 00 | |
| June 26 | 35 37 | 21 45 | 131 39 | 5 00 | |
| 29 | 37 20 | 24 35 | 134 29 | 10 19* | |
| July 1 | 39 43 | 26 08 | 136 02 | 7 42* | |
| Aug. 9 | 48 17 | 15 17 | 125 11 | 18 18 | Saw land at great distance. [Off Cape Flattery—Sch.] |
| 15 | 42 37 | 14 26 | 124 20 | 5 30 | Coast not visible. [Supposed should be 15° 30′—Sch.] |
| 21 | 39 46 | ---- | ---- | 11 15 | Cape seen; thought to be Mendocino. [Probably Point Delgado $\lambda = -124° 15′$—Sch.] |
| Oct. 10 | 36 48 | 13 | 123 | 11 00 | [Off Santa Cruz—Sch.] |
| 12 | 36 14 | 12 03 | 121 57 | 11 00 | [Off Point Sur—Sch.] |

### *Frigate Santiago and schooner Sonora.*

[Commander Don Bruno de Heceta.]

| Date. | Lat. north. | Long. west of San Blas. | Long. west from Greenwich. | Variation north-east. | Remarks. |
|---|---|---|---|---|---|
| 1775. | ° ′ | ° ′ | ° ′ | ° ′ | |
| Mar. 16 | 21 25 | 5 00 | 110 17 | 4 30 | [Off Cape San Lucas—Sch. |
| | | *Long. west of San Lucas.* | | | |
| 25 | 20 35 | 4 02 | 113 56 | 4 30* | |
| 26 | 20 10 | 2 58 | 112 52 | 4 30* | |
| 27 | 19 49 | 0 50 | 110 44 | 5 00 | [Near Socorro Island—Sch.] |
| Apr. 1 | 18 33 | 0 37 | 110 31 | 5 00 | |
| 2 | 18 33 | 0 48 | 110 42 | 5 13* | |
| 23 | 21 21 | 15 15 | 125 09 | 6 00 | |
| 30 | 25 57 | 21 22 | 131 16 | 7 00 | |
| May 1 | 26 31 | 22 07 | 132 01 | 7 00 | |
| 11 | 32 10 | 27 50 | 137 44 | 8 00 | |
| 31 | 37 59 | 21 35 | 131 29 | 10 00 | |
| June 1 | 38 14 | 21 12 | 131 06 | 10 00 | |
| 2 | 39 30 | 20 26 | 130 20 | 12 00 | |
| 4 | 40 13 | 18 35 | 128 29 | 10 30* | |
| 7 | 41 45 | 15 19 | 125 13 | 14 00 | [Off Point St. George—Sch.] |
| 8 | 41 31 | 14 53 | 124 47 | 14 30* | |
| 20 | 40 59 | 14 21 | 124 15 | 14 00 | [Off Trinidad—Sch.] |
| 26 | 39 20 | 20 40 | 130 34 | 13 00 | |
| July 2 | 42 15 | 21 49 | 131 43 | 14 00 | |
| 6 | 44 14 | 20 47 | 130 41 | 15 00 | |
| 7 | 46 10 | 21 06 | 131 00 | 16 00 | |
| 10 | 47 35 | 18 28 | 128 22 | 17 00 | |
| 13 | 47 28 | 16 34 | 126 28 | 17 00 | |
| 15 | 47 23 | 16 40 | 126 34 | 17 30* | |
| 18 | 46 32 | 18 32 | 128 26 | 16 00 | |
| 23 | 45 41 | 24 24 | 134 18 | 15 00 | |
| 27 | 47 05 | 24 59 | 134 53 | 16 00* | |
| Aug. 6 | 47 04 | 18 55 | 128 49 | 18 00* | [Off coast of Washington Terr.; probably in λ = — 128° 30′—Sch.] |
| 9 | 49 11 | 18 35 | 128 29 | 19 00* | [Off Vancouver Island, probably in λ = — 128° 00′—Sch.] |
| 11 | 49 42 | 18 35 | 128 29 | 18 00* | In sight of land. [Probably in λ = — 128° 00′—Sch.] |
| 17 | 46 15 | 15 38 | 125 32 | 17 00* | In sight of entrance, called Hecata. [Off Cape Disappointment, mouth of Columbia River, corrected long. λ = — 124° 20′—Sch.] |
| 21 | 42 25 | 15 09 | 125 03 | 17 00 | |
| 27 | 37 54 | 14 30 | 124 24 | 16 00 | [Off Punta Reyes, probably in λ = — 123° 20′—Sch.] |
| Aug. 1 | 46 34 | 25 56 | 135 50 | 16 00 | Observations on schooner. |
| 9 | 49 09 | 29 07 | 139 01 | 17 00 | |
| 10 | 50 18 | 29 54 | 139 48 | 18 00 | |
| 13 | 53 54 | 31 07 | 141 01 | 19 00 | |
| 15 | 56 08 | 29 47 | 139 41 | 19 00 | |
| 22 | 57 57 | 33 03 | 142 57 | 20 00 | |
| 23 | 57 08 | 30 50 | 140 44 | 22 00* | |
| 24 | 56 01 | 28 46 | 138 40 | 24 00* | |
| 28 | 55 36 | 29 39 | 139 33 | 23 00* | |
| Sept. 6 | 54 42 | 31 27 | 141 21 | 22 00 | |

*Frigate Santiago and schooner Sonora.—Continued.*

[Commander Don Bruno de Heceta.]

| Date. | Lat. north. | Long. west of San Lucas. | Long. west from Greenwich. | Variation north-east. | Remarks. |
|---|---|---|---|---|---|
| 1775. | ° ′ | ° ′ | ° ′ | ° ′ | |
| Sept. 7 | 54 53 | 31 56 | 141 50 | 23 00 | |
| 9 | 54 32 | 30 22 | 140 16 | 22 00 | |
| 10 | 54 06 | 30 10 | 140 04 | 21 00 | |
| 12 | 52 00 | 26 54 | 136 48 | 20 00 | |
| 18 | 47 50 | 19 05 | 128 59 | 19 00 | |
| 25 | 44 19 | 16 02 | 125 56 | 18 00* | Off Cape Orford or Blanco. |
| 27 | 42 37 | 16 41 | 126 35 | 17 00 | In sight land. [Probably in $\lambda = -124° 34'$—Sch.] |
| 30 | 39 42 | 16 11 | 126 05 | 16 00 | In sight coast. [Off Point Delgado, Shelter Cove; probably in $\lambda = -124° 15'$—Sch.] |
| Oct. 6 | 37 43 | 14 14 | 124 08 | 15 00 | [Off Punta Reyes, probably in $\lambda = -123° 45'$—Sch.] |
| 7 | 36 42 | 13 47 | 123 41 | 14 00 | [Off Bay of Monterey, probably in $\lambda = -123° 15'$—Sch.] |

*Sr. Virey and Antonio Bucareli.*

[Commanding two frigates, Exp'n of 1779.]

| Date. | Lat. north. | Long. west of San Lucas. | Long. west from Greenwich. | Variation north-east. | Remarks. |
|---|---|---|---|---|---|
| 1779. | ° ′ | ° ′ | ° ′ | ° ′ | |
| Feb. 27 | 20 33 | 2 27 | 112 21 | 5 00 | [Off Socorro—Sch.] |
| Mar. 1 | 20 21 | 9 | 110 03 | 5 30 | [Off Socorro—Sch.] |
| 4 | 20 00 | 1 40 | 111 34 | 6 00* | [Off Socorro—Sch.] |
| 9 | 20 08 | 6 57 | 116 51 | 7 00 | |
| 15 | 22 00 | 13 02 | 122 56 | 8 00 | |
| 22 | 24 54 | 18 52 | 128 46 | 9 00 | |
| 26 | 28 01 | 22 53 | 132 47 | 9 30 | |
| 30 | 30 10 | 25 19 | 135 13 | 10 00 | |
| Apr. 4 | 31 29 | 28 14 | 138 08 | 11 00 | |
| 10 | 34 23 | 30 16 | 140 10 | 11 30 | |
| 13 | 36 03 | 31 51 | 141 45 | 12 00 | |
| 14 | 37 19 | 32 04 | 141 58 | 13 00 | |
| 16 | 39 25 | 31 50 | 141 44 | 14 00 | |
| 20 | 42 58 | 30 28 | 140 22 | 15 00 | |
| 24 | 48 30 | 30 46 | 140 40 | 16 00 | |
| 25 | 49 25 | 30 40 | 140 34 | 17 00 | |
| 26 | 51 06 | 31 20 | 141 14 | 18 00 | |
| 27 | 53 14 | 32 00 | 141 54 | 19 30 | |
| 28 | 55 01 | 31 57 | 141 51 | 21 00 | |
| 29 | 55 15 | 31 33 | 141 27 | 22 30 | |
| May 2 | 55 22 | 27 03 | 136 57 | 23 30* | |
| July 2 | 54 16 | 28 02 | 137 56 | 23 30 | |
| 3 | 53 23 | 28 49 | 138 43 | 22 30 | |
| 4 | 53 33 | 29 03 | 138 57 | 22 00 | |

*San Virey and Antonio Bucareli.—Continued.*

[Commanding two frigates, Exp. of 1779.]

| Date. | Lat. north. | Long. west of San Lucas. | Long. west from Greenwich. | Variation north-east. | Remarks. |
|---|---|---|---|---|---|
| 1779. | ° ′ | ° ′ | ° ′ | ° ′ | |
| July 5 | 54 36 | 30 22 | 140 16 | 22 30 | |
| 6 | 55 23 | 31 25 | 141 19 | 23 00 | |
| 7 | 56 13 | 31 58 | 141 52 | 23 30 | |
| 8 | 57 21 | 33 28 | 143 22 | 24 00 | |
| 9 | 58 05 | 33 51 | 143 45 | 25 30 | |
| 10 | 58 26 | 34 03 | 143 57 | 26 00 | |
| 18 | 59 48 | 38 21 | 148 15 | 26 30* | |
| 29 | 59 35 | 40 32 | 150 26 | 26 00 | |
| Aug. 9 | 57 59 | 42 13 | 152 07 | 27 00* | |
| 11 | 57 25 | 40 06 | 150 00 | 26 00 | |
| 17 | 56 36 | 34 25 | 144 19 | 25 30 | |
| 19 | 55 17 | 30 54 | 140 48 | 24 30 | |
| 20 | 55 09 | 30 18 | 140 12 | 23 30 | |
| 21 | 54 36 | 29 23 | 139 17 | 23 00 | |
| 22 | 54 12 | 28 20 | 138 14 | 22 30 | |
| 23 | 52 39 | 28 00 | 137 54 | 21 30 | |
| 24 | 51 16 | 26 53 | 136.47 | 20 00 | |
| 25 | 50 46 | 26 26 | 136 20 | 19 30 | |
| 26 | 49 39 | 25 42 | 135 36 | 19 30 | |
| 27 | 49 03 | 25 11 | 135 05 | 19 00 | |
| 28 | 48 38 | 24 42 | 134 36 | 18 30 | |
| 29 | 48 01 | 24 06 | 134 00 | 18 00 | |
| 30 | 46 40 | 23 09 | 133 03 | 17 30 | |
| 31 | 46 27 | 21 56 | 131 50 | 16 30 | |
| Sept. 1 | 45 19 | 20 32 | 130 26 | 16 30* | |
| 2 | 43 45 | 18 52 | 128 46 | 16 00 | [Off coast of Oregon—Sch.] |
| 3 | 42 03 | 16 56 | 126 50 | 15 30 | |
| 4 | 40 56 | 15 32 | 125 25 | 15 00 | |
| 5 | 39 39 | 14 31 | 124 25 | 14 00 | [Off coast of California—Sch.] |
| 6 | 39 28 | 14 42 | 124 36 | 13 30 | |
| 10 | 38 56 | 14 04 | 123 58 | 13 00 | [Off Punta Arena—Sch.] |
| Oct. 31 | 37 36 | 13 17 | 123 11 | 13 00 | [Near the Farallon Islands—Sch.] |
| Nov. 1 | 37 10 | 13 12 | 123 06 | 12 30 | [Off Halfmoon Bay—Sch.] |
| 2 | 36 02 | 12 43 | 122 37 | 12 00 | [Off Point Sur—Sch. |
| 3 | 34 51 | 12 19 | 122 13 | 11 00 | [Off San Louis Bay—Sch.] |
| 6 | 30 56 | 9 57 | 119 51 | 10 30 | |
| 7 | 29 46 | 9 02 | 118 56 | 10 00 | [Off Lower California, Mexico—Sch.] |
| 8 | 28 17 | 7 33 | 117 27 | 9 30 | |
| 9 | 27 05 | 6 37 | 116 31 | 8 30 | |
| 10 | 26 06 | 5 39 | 115 33 | 7 30 | |
| 11 | 25 17 | 4 45 | 114 39 | 7 00 | |
| 14 | 23 02 | 1 08 | 111 02 | 6 30 | |
| 15 | 22 50 | 0 14 | 110 08 | 6 00 | On the 15th they found themselves in the neighborhood of Cape San Lucas, and on standing in found that their point was only four leagues to the east of the demarcation of the Cape; made at 6 p. m. west longitude. |

*Sr. Virey and Antonio Bucareli.—Continued.*

[Commanding two frigates, Exp.'n of 1779.]

| Date. | Lat. north. | Long. west of San Lucas. | Long. west from Greenwich. | Variation north-east. | Remarks. |
|---|---|---|---|---|---|
| 1779. | ° ′ | ° ′ | ° ′ | ° ′ | |
| Nov. 16 | 22 31 | 0 38 | 110 32 | 5 30 | |
| 18 | 21 49 | 3 38 | 113 32 | 5 00 | |

[Same for frigate Favorita.]

| Date. | Lat. north. | Long. west of San Lucas. | Long. west from Greenwich. | Variation north-east. | Remarks. |
|---|---|---|---|---|---|
| 1779. | | | | | |
| Feb. 27 | 20 34 | 1 52 | 111 46 | 5 00 | [Off Socorro—Sch.] |
| Mar. 2 | 20 26 | 4 35½ | 114 29 | 6 00 | [Off Santa Rosa—Sch.] |
| 8 | 20 11 | 10 15 | 120 09 | 7 00 | |
| 13 | 21 12 | 15 56 | 125 44 | 8 00 | |
| 22 | 24 50 | 23 12 | 133 06 | 9 00 | |
| 26 | 28 11 | 26 51½ | 136 45 | 9 30 | |
| 31 | 30 18 | 30 19 | 140 13 | 10 00 | |
| Apr. 7 | 32 58½ | 32 24 | 142 18 | 11 15 | |
| 12 | 35 59 | 35 32½ | 145 26 | 12 00 | |
| 14 | 38 57½ | 36 01 | 145 55 | 14 00 | |
| 21 | 44 56 | 33 50½ | 143 44 | 15 00 | |
| 22 | 46 11½ | 33 24½ | 143 18 | 15 30 | |
| 23 | 48 36 | 33 38 | 143 32 | 16 00 | |
| 24 | 49 21 | 34 24 | 144 18 | 17 30 | |
| 25 | 51 04 | 34 20 | 144 14 | 18 00 | |
| 26 | 53 14 | 35 05 | 144 59 | 19 30 | |
| 27 | 51 01 | 35 46 | 145 40 | 21 15 | |
| 28 | 55 13 | 35 46 | 145 40 | 22 30 | |
| 29 | 55 31 | 35 08 | 145 02 | 23 30 | |
| May 2 | 55 15 | 31 53 | 141 47 | 25 00 | Difference in the standing in to the shore up to hour of casting anchor, 45′ in longitude farther east. |
| July 2 | 54 15⅔ | 32 55 | 142 49 | 22 00 | |
| 5 | 54 32 | 35 10½ | 145 04 | 22 30 | |
| 6 | 55 19 | 36 12 | 146 06 | 23 00 | |
| 8 | 57 15 | 38 15 | 148 09 | 24 30 | |
| 9 | 58 06 | 38 47 | 148 41 | 25 30 | |
| 10 | 58 29 | 38 45 | 148 39 | 26 00 | |
| 13 | 58 12 | 39 39½ | 149 33 | 25 30 | |
| 14 | 58 07⅓ | 39 58 | 149 32 | 26 00 | |
| 17 | 59 46 | 42 01½ | 151 55 | 26 30 | |
| 18 | 59 47 | 43 23 | 153 17 | 27 00 | |
| 19 | 59 56 | 43 51½ | 153 45 | 25 30 | |
| Aug. 8 | 58 42 | 47 30 | 157 24 | 25 00 | |
| 9 | 57 58 | 46 42½ | 156 36 | 25 30 | |
| 10 | 57 57½ | 46 20 | 156 14 | 27 00 | |
| 16 | 57 52 | 40 14 | 150 08 | 26 00 | |
| 18 | 56 11 | 38 43 | 148 37 | 25 30 | |
| 19 | 55 55½ | 37 03 | 146 57 | 24 00 | |
| 20 | 55 08 | 35 15 | 145 09 | 23 00 | |

*Sr. Virey and Antonio Bucareli.—Continued.*

[Commanding two frigates, Exp'n of 1779.]

| Date. | Lat. north. | Long. west of San Lucas. | Long. west from Greenwich. | Variation north-east. | Remarks. |
|---|---|---|---|---|---|
| 1779. | ° ′ | ° ′ | ° ′ | ° ′ | |
| Aug. 21 | 54 34½ | 34 35 | 144 29 | 23 00 | |
| 22 | 54 11 | 33 45 | 143 39 | 22 30 | |
| 23 | 52 37 | 33 02½ | 142 56 | 21 30 | |
| 24 | 51 16 | 32 19 | 142 13 | 20 00 | |
| 25 | 50 47 | 31 13 | 141 07 | 19 30 | |
| 26 | 49 40 | 30 43 | 140 37 | 19 00 | |
| 27 | 49 03½ | 29 55 | 139 49 | 19 00 | |
| 28 | 48 37⅓ | 29 24 | 139 18 | 18 30 | |
| 29 | 48 00 | 28 55 | 138 49 | 18 00 | |
| 30 | 47 24 | 28 20⅓ | 138 14 | 17 00 | |
| 31 | 46 25 | 27 22⅔ | 137 17 | 16 30 | |
| Sept. 1 | 45 17½ | 26 09 | 136 03 | 16 00 | |
| 2 | 43 44 | 24 45 | 134 39 | 16 54 | |
| 3 | 42 03 | 23 07 | 133 01 | 15 30 | [Defective longitudes—Sch.] |
| 4 | 40 54 | 21 10 | 131 04 | 14 30 | |
| 5 | 39 38 | 19 46 | 129 40 | 14 00 | |
| 6 | 39 26 | 19 54 | 129 48 | 13 30 | |
| 9 | 38 59 | 19 25½ | 129 19 | 13 00 | |
| 14 | 37 49 | 19 00 | 128 54 | 13 00 | San Francisco. [Corrected longitude λ = —122° 45′—Sch.] |
| Oct. 31 | 37 35 | 18 14 | 128 08 | 13 00 | |
| Nov. 2 | 36 01 | 17 40 | 127 34 | 12 30 | |
| 3 | 34 50 | 17 16 | 127 10 | 12 00 | |
| 4 | 33 50 | 16 45 | 126 39 | 11 30 | |
| 5 | 32 02 | 15 47 | 125 41 | 11 00 | |
| 6 | 30 35 | 14 54 | 124 48 | 11 00 | |
| 7 | 29 46 | 13 59 | 123 53 | 10 30 | |
| 8 | 28 16 | 12 30 | 122 24 | 10 00 | |
| 9 | 27 04 | 11 33 | 121 27 | 9 30 | |
| 10 | 26 25 | 10 36 | 120 30 | 8 30 | |
| 11 | 25 16 | 9 42 | 119 36 | 7 30 | |
| 12 | 24 22 | 8 38 | 118 32 | 7 00 | |
| 13 | 23 27 | 7 26 | 117 20 | 7 00 | [Off Lower California—Sch.] |
| 14 | 23 01 | 6 06 | 116 00 | 6 30 | |
| 15 | 22 49 | 5 13 | 115 07 | 6 00 | |
| 16 | 22 30 | 4 24 | 114 18 | 5 30 | |
| 17 | 22 16 | 2 46 | 112 40 | 5 30 | |
| 18 | 21 48 | 1 32 | 111 26 | 5 00 | |
| 19 | 21 37 | 0 54 | 110 48 | 5 00 | |
| 20 | 21 33 | 0 26 | 110 20 | 5 00 | [Off San Lucas—Sch.] |

*Voyage of 1788, in vessels Princessa and San Carlos, northern coast of California.*

[Princessa commanded by Ensign of the Navy Don Esteban Martinez, and San Carlos by First Mate Don Gonzalo Lopez de Haro. Vessels sailed on the 8th of March, 1788, from port of San Blas, situated under latitude 21° 30′, and 107° 6′ to west of Paris (104° 46′ to west of Greenwich), and 5° to east of Cape San Lucas, in the peninsula of California.]

| Date. | Lat. north. | Long. west of San Lucas. | Long. west from Greenwich. | Variation north-east. | Remarks. |
|---|---|---|---|---|---|
| 1788. | ° ′ | ° ′ | ° ′ | ° ′ | |
| Mar. 9 | 21 30 | 5 00† | 104 54 | 5 00 | [† Probably east of San Lucas, near San Blas.—SCH.] |
| 18 | 20 14 | 2 50 | 112 44 | 5 30 | [Off Lower California.—SCH.] |
| 19 | 20 16 | 3 55 | 113 49 | 5 30* | |
| 23 | 20 25 | 6 44 | 116 38 | 6 00* | |
| 24 | 20 38 | 7 51 | 117 45 | 6 00 | |
| 28 | 21 38 | 12 12 | 122 06 | 7 00 | |
| 29 | 21 58 | 13 30 | 123 24 | 8 00 | |
| 30 | 22 39 | 14 58 | 124 52 | 8 00 | |
| 31 | 23 16 | 16 18 | 126 12 | 7 37* | |
| Apr. 2 | 24 06 | 18 16 | 128 10 | 8 00* | |
| 3 | 24 27 | 19 04 | 128 58 | 8 30 | |
| 6 | 26 46 | 22 23 | 132 17 | 9 00 | |
| 9 | 28 32 | 25 11 | 135 05 | 10 00* | |
| 15 | 30 54 | 29 36 | 139 30 | 11 22* | |
| 18 | 34 55 | 30 17 | 140 11 | 12 00 | |
| 21 | 36 32 | 31 24 | 141 18 | 12 00 | |
| 22 | 37 37 | 31 46 | 141 40 | 13 00 | |
| 23 | 39 07 | 31 58 | 141 52 | 16 08 | |
| 27 | 42 40 | 32 39 | 142 33 | 17 47* | |
| 28 | 43 23 | 33 03 | 142 57 | 18 30 | |
| 29 | 44 23 | 33 10 | 143 04 | 19 00 | |
| 30 | 45 53 | 32 49 | 142 43 | 19 30 | |
| May 2 | 48 09 | 32 26 | 142 20 | 20 13* | |
| 4 | 51 20 | 33 24 | 143 18 | 21 00 | |
| 7 | 53 31 | 31 59 | 141 53 | 22 00 | |
| 13 | 56 21 | 35 30 | 145 24 | 23 00 | |
| 15 | 58 37 | 36 44 | 146 38 | 24 00 | Mount St. Elias, north-east one-fourth north. |
| 17 | 60 10 | 37 41 | 147 35 | 25 00 | |
| 19 | 59 49 | 37 09 | 147 03 | 25 00 | |
| 23 | 59 35 | 38 43 | 148 37 | 26 00 | |
| Aug. 24 | 53 18 | 53 20 | 163 14 | 22 30 | |
| 27 | 52 33 | 46 51 | 156 45 | 22 00 | |
| 28 | 52 03 | 45 08 | 155 02 | 21 00 | |
| Sept. 1 | 49 46 | 33 04 | 142 58 | 20 00 | |
| 4 | 47 08 | 26 55 | 136 49 | 19 00 | |
| 8 | 42 15 | 22 23 | 132 17 | 18 00 | |
| 9 | 41 28 | 21 06 | 131 00 | 17 00 | |
| 13 | 40 03 | 15 38 | 125 32 | 16 00 | [Off Point Delgado.—SCH.] |
| Oct. 17 | 36 32 | 9 24 | 119 18 | 14 00 | |
| 20 | 35 17 | 9 11 | 119 05 | 13 00 | [Doubtful longitude.—SCH.] |
| Nov. 17 | 33 19 | 7 13 | 117 07 | 12 00 | |
| 19 | 33 27 | 7 58 | 117 52 | 11 00 | [Near San Pedro.—SCH.] |

*Voyage of 1788, in vessels Princessa and San Carlos, northern coast of California.—Continued.*

| Date. | Lat. north. | Long. west of San Lucas. | Long. west from Greenwich. | Variation north-east. | Remarks. |
|---|---|---|---|---|---|
| 1788. | ° ′ | ° ′ | ° ′ | ° ′ | |
| Nov. 21 | 29 45 | 6 26 | 116 14 | 10 00 | [Off San Geronimo.—SCH.] |
| 24 | 25 43 | 2 41 | 112 35 | 9 00 | |
| 25 | 24 37 | 1 42 | 111 36 | 7 00 | [Near Santa Maria Bay.--SCH.] |
| 27 | 23 48 | 0 27† | 109 27 | 6 30 | † East. [Near Cape Punta Arenas.—SCH.] |

*Voyage of the packet San Carlos from Ounalaska to San Blas (coincidently with frigate Princessa).*

| | | | | | |
|---|---|---|---|---|---|
| Aug. 28 | 54 02 | 54 06 | 164 00 | 19 00 | |
| 31 | 51 26 | 48 39 | 158 33 | 18 43* | |
| Sept. 2 | 51 58 | 45 32 | 155 26 | 19 00 | |
| 5 | 51 23 | 37 34 | 147 28 | 18 30 | "The 4th, at 10 p. m., the horizon was illuminated as if it were the moon in opposition; at 10¼ commenced to diminish from the west. That day there were seen several signs of land." |
| 7 | 50 54 | 31 27 | 141 21 | 18 00 | |
| 10 | 48 25 | 24 48 | 134 42 | 17 00 | |
| 14 | 42 37 | 23 46 | 133 40 | 16 00 | |
| 16 | 42 08 | 23 36 | 133 30 | 16 30 | |
| 18 | 42 01 | 22 23 | 132 17 | 16 00 | |
| 20 | 41 08 | 20 08 | 130 02 | 13 00* | |
| 21 | 40 20 | 20 20 | 130 14 | 12 30 | |
| 22 | 39 12 | 19 23 | 129 17 | 12 00 | |
| 23 | 38 13 | 17 52 | 127 46 | 11 30 | |
| 24 | 37 06 | 16 41 | 126 35 | 11 00 | |
| 25 | 36 11 | 15 30 | 125 24 | 10 30 | [Off Monterey.—SCH.] |
| 26 | 35 15 | 14 18 | 124 12 | 10 00 | |
| 29 | 32 38 | 10 56 | 120 50 | 9 00 | |
| Oct. 1 | 31 44 | 8 46 | 118 40 | 8 30 | [Off San Diego.—SCH.] |
| 3 | 30 37 | 6 28 | 116 22 | 8 00 | |
| 7 | 28 16 | 9 10 | 119 03 | 6 53 | "Saw island of Guadaloupe, and, according to calculations observed, it was found in 9° 19′ of longitude west of San Lucas. This island is 143 leagues, with eastern projection in the same situation as the vessel, so that they found, according to their reckoning, a greater longitude between Ounalaska and Guadaloupe than that which is assigned to it; but this calculation is doubtless very erroneous." |
| 8 | 28 16 | 9 19 | 119 12 | | |
| 8 | 27 04 | 7 07 | 117 01 | 6 00* | |
| 9 | 25 43 | 5 18 | 115 12 | 5 00 | |
| 10 | 25 01 | 4 41 | 114 35 | 5 30 | |
| 11 | 24 43 | 4 21 | 113 55 | 5 20 | |
| 12 | 24 12 | 3 36 | 113 30 | 5 10 | |
| 13 | 23 37 | 2 53 | 112 47 | 5 00 | |
| 16 | 22 53 | †1 13 | 108 41 | 5 00 | [† East. "This day they saw Cape San Lucas, which was found in 93° longitude, between the demarkation and its point." |
| 17 | 22 43 | 1 17 | 108 37 | 4 28 | [Off Mazatlan and San Blas.—SCH.] |
| 18 | 22 15 | 2 45 | 107 09 | 4 28 | |
| 19 | 21 56 | 4 08 | 105 46 | 4 28 | "This day they found themselves in the vicinity of Santa Maria Islands, and anchored southward of them, at San Blas, on the 22d." |

### *Voyage from San Blas to Nutka*, 1790.

[The 13th of February, 1790, there set sail from the port of San Blas, situated in 21° 30′ latitude, and to the east of San Lucas 5°, or, what is the same, to the west of Paris 107° 06′ (west of Greenwich 104° 46′), the three vessels of the King—frigate Concepcion, commanded by the Lieutenant of the Navy Don Francesco Eliza, commandante of the expedition; the packet San Carlos, commanded by Lieutenant Don Salvada Fidalgo; and sloop Princess Royal, commanded by Naval Ensign Don Manuel Quimper.]

| Date. | Lat. north. | Long. west of San Lucas. | Long. west from Greenwich, | Variation north-east. | Remarks. |
|---|---|---|---|---|---|
| 1790. | ° ′ | ° ′ | ° ′ | ° ′ | |
| Feb. 6 | 21 13 | 3 40† | 106 14 | 6 00 | [† Supposed east of San Lucas. Off San Blas.—SCH.] Passed short distance to south Santa Maria Islands. |
| 13 | 20 29 | 4 15 | 114 09 | 6 55 | [Off Lower California.—SCH.] |
| 15 | 20 09 | 5 59 | 115 53 | 6 49 | |
| 19 | 21 41 | 10 49 | 120 43 | 7 00 | |
| 21 | 22 29 | 13 50 | 123 44 | 7 30 | |
| 22 | 23 08 | 15 26 | 125 20 | 8 00 | |
| 26 | 27 08 | 20 27 | 130 21 | 8 30 | |
| Mar. 2 | 30 07 | 23 12 | 133 06 | 9 00 | |
| 4 | 31 00 | 25 20 | 135 14 | 9 30 | |
| 6 | 33 37 | 27 41 | 137 35 | 10 00 | |
| 7 | 34 55 | 27 48 | 137 42 | 10 30 | |
| 8 | 35 30 | 27 29 | 137 23 | 11 00 | |
| 13 | 40 10 | 27 20 | 137 14 | 11 30 | |
| 24 | 49 46 | 22 35 | 132 29 | 17 30 | This day land was seen distant 8 or 9 leagues. |
| 25 | 49 56 | 21 30 | 131 24 | 18 09 | |
| 27 | 49 55 | 17 41 | 127 35 | 17 46 | Anchored in 35 fathoms of water 2 leagues from the coast, the Point Boisset bearing towards them from the west ¼ northwest, 3° west. [Position to the north and west of Nootka, Vancouver Island.—SCH.] |

### *Record of the packet Philipino, commanded by Fidalgo, in his voyage of discovery, in* 1790, *from Nutka to Prince William, Cook's River, and return to Monterey.*

| | | | | | |
|---|---|---|---|---|---|
| May 4 | | | | | Set sail from Nutka. |
| 5 | 48 59 | 18 03 | 127 57 | 17 04 | [Off Vancouver Island.—SCH.] |
| 6 | 48 41 | 18 30 | 128 24 | 18 00 | |
| 7 | 49 00 | 18 56 | 128 50 | 18 30 | |
| 12 | 47 03 | 22 58 | 132 52 | 17 30 | |
| 17 | 51 48 | 33 42 | 143 36 | 20 13 | |
| 20 | 56 33 | 35 17 | 145 11 | 22 30 | |
| 23 | 60 12 | 36 37 | 146 31 | 26 00 | The 23, at noon, land was seen, being northwest point of Prince William, so that their reckoning agreed exactly with the true longitude. [Off Port Etches.—SCH.] |
| July 1 | 59 38 | 39 18 | 149 12 | 25 00 | |
| 10 | 58 10 | 42 13 | 152 07 | 22 10 | Camacho Island in sight. |
| 19 | 58 32 | 39 10 | 149 04 | 24 00 | |
| 25 | 56 33 | 35 04 | 144 58 | 23 00 | |
| | [Then several apparent approximations, and] | | | | |
| Aug. 9 | 37 35 | 13 28 | 123 22 | 14 30 | They found themselves at the Farallones, off San Francisco, and consequently in latitude 37° 36′, and to the west of San Lucas 13° 22′, their real position according with the reckoning. |
| | [Daily journal to Monterey, and then following record from Monterey to San Blas.] | | | | On the 25th they departed from that port, which is in latitude 36° 42′, and 17° west of San Lucas. |
| Oct. 27 | 35 17 | 13 06 | 123 00 | 12 00 | |
| 28 | 32 45 | 11 54 | 121 48 | 11 00 | |

*Record of the packet Philipino, commanded by Fidalgo, in his voyage of discovery, in 1790.—Continued.*

| Date. | Lat. north. | Long. west of San Lucas. | Long. west from Greenwich. | Variation north-east. | Remarks. |
|---|---|---|---|---|---|
| 1790. | ° ′ | ° ′ | ° ′ | ° ′ | |
| Oct. 29 | 31 02 | 10 30 | 120 24 | 9 00 | |
| 30 | 29 23 | 9 22 | 119 16 | 8 30 | |
| Nov. 4 | 24 50 | 5 38 | 115 32 | 8 00 | To-day they came in sight of the Farallones of Aligos. |
| 6 | 23 45 | 4 13 | 114 07 | 9 00 | |
| 7 | 23 07 | 2 28 | 112 22 | 8 30 | |
| 9 | 22 41 | 1 31 | 111 25 | 7 30 | |
| 10 | 22 46 | 1 52† | 108 02 | 7 00 | [†Probably east of San Lucas.—SCH.] |
| 11 | 22 43 | 2 53 | 107 01 | 6 00 | |
| 12 | 22 30 | 3 39 | 106 15 | 5 00 | To-day they came between the Santa Maria Islands and the coast. |
| 14 | 21 30 | 5 00 | 104 54 | | West Cape San Lucas; anchored at San Blas. |

*Sloop Princess Royal, voyage from Santa Cruz to Straits of Fuca, year 1790, commanded by Don Manuel Quimper.*

| | | | | | |
|---|---|---|---|---|---|
| Aug. 6 | 48 11 | 15 15 | 125 09 | 18 00 | [Off Vancouver Island.—SCH.] (Aug. 6–12) |
| 7 | 48 17 | 15 18 | 125 12 | 17 00 | |
| 8 | 48 26 | 16 30 | 126 24 | 15 00 | |
| 9 | 48 54 | 16 59 | 121 53 | 15 30 | |
| 10 | 49 30 | 17 21 | 127 15 | 16 00 | |
| 12 | 49 39 | 17 50 | 127 44 | 17 00 | |
| 17 | 48 48 | 19 17 | 129 11 | 16 30 | |
| 20 | 44 53 | 18 28 | 128 22 | 15 30 | |
| 23 | 43 11 | 18 02 | 127 56 | 15 00 | |
| 29 | 41 20 | 16 03 | 125 57 | 14 30 | |
| 30 | 39 22 | 15 31 | 125 25 | 13 45 | |
| 31 | 37 32 | 13 46 | 123 40 | 13 20 | |
| Sept. 1 | 37 07 | 12 34 | 122 28 | 13 00 | The Farallones of Straits of Fuca were seen 8 leagues farther to the east than the reckoning. |

G. D.

# APPENDIX No. 8.

GEOGRAPHICAL POSITIONS OF TRIGONOMETRICAL POINTS IN THE STATES OF MASSACHUSETTS AND RHODE ISLAND, DETERMINED BY THE UNITED STATES COAST AND GEODETIC SURVEY BETWEEN THE YEARS 1835 AND 1885, AND INCLUDING THOSE DETERMINED BY THE BORDEN SURVEY IN THE YEARS 1832 TO 1838.

## *INTRODUCTION AND EXPLANATION OF THE TABLE OF POSITIONS.*

By CHARLES A. SCHOTT, Assistant.

The geographical positions herewith presented are located in the States of Massachusetts and Rhode Island, and are the results to date of the computation and final adjustment of the primary and subordinate triangulations carried on by the United States Coast and Geodetic Survey between the years 1835 and 1885; to these have been added the results from a recomputation of the earlier triangulation, executed by Mr. Simeon Borden, by authority of the State of Massachusetts, between the years 1832 and 1838, and comprising all of his principal points, the records of many of the subordinate points not having been recoverable.

All results depend on the standard geodetic data of the Survey, viz:

*Unit of length.*—The metre, and in particular the French committee (iron) metre brought here by Superintendent F. R. Hassler; see Appendix No. 7, Coast Survey Report for 1867.

*Surface of reference.*—The spheroid of rotation deduced by Captain A. R. Clarke, R. E., in 1866, as resembling most nearly the earth's size and figure; see comparisons of standards of length, etc., London, 1866; also Appendix No. 7, Coast and Geodetic Survey Report for 1884.

*The standard latitude.*—Is the same as that of the primary triangulation of the Atlantic Coast, viz: Principio $\varphi_0=39° 35' 36''.692$; see Appendix No. 8, Coast and Geodetic Survey Report for 1879.

*The standard azimuth.*—Is the same as that of the primary triangulation, viz: Principio to Turkey Point $\alpha_0=1° 34' 36''.413$; see above report.

*The standard longitude.*—Is the telegraphic longitude of the North American system, depending directly on Greenwich, England, for which see the above report, also Appendix No. 11, Coast and Geodetic Survey Report for 1884. We have for Principio $\lambda_0=76° 00' 16''.407$ west from Greenwich.

The former publications by this office of positions in the two States, in Appendix No. 12, Coast Survey Report for 1851, Appendix No. 15, Coast Survey Report for 1864 and Appendix No. 13, Coast Survey Report for 1868, are therefore superseded, as based upon a different spheroid as well as upon different standard data, nor had these old results been thoroughly adjusted.

Respecting elevations of points above the average tidal level of the Atlantic, their publication must be reserved for a later time, when additional data will be available for a reduction and discussion of the vertical measures of the Survey.

Descriptions of stations can generally be furnished by the office on application.

The method of treatment of the observations by the computer may in general be briefly stated as follows: Starting from the results of the primary triangulation known as the oblique arc of the Atlantic, where the same crosses the boundaries of the States of Massachusetts and Rhode Island, and inclusive of the subordinate primary triangulations of these States, 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 are treated together in one least square adjustment. In this manner point after point 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 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, but generally without least 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 triangulation of the State of Massachusetts by S. Borden was well executed in its time; yet material strength was given to it by the introduction of numerous Coast and Geodetic Survey lines, serving as so many base lines, and by developing the same on Clarke's spheroid with the astronomical standard data of the Coast and Geodetic Survey. Thus modernized and strengthened, it is as serviceable now as then. In consequence of its less perfect measures in the earlier years and in particular covering that part of the triangulation which lies in the vicinity of the base, that length was deduced from the Coast and Geodetic Survey work; but it proved so nearly identical with the result of the direct measure by Mr. Borden that the condition of perfect accord was included in the figure adjustment and satisfied.

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, Coast and Geodetic Survey 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; they are:*

$$\begin{cases} \Delta\varphi = -s\,.\cos\alpha\,.\,\mathrm{B} - s^2\,.\sin^2\alpha\,.\,\mathrm{C} - (\Delta\varphi)^2\,\mathrm{D} + h\,.\,s^2\,.\sin^2\alpha\,.\,\mathrm{E} \\ \Delta\lambda\ = +s\,.\sin\alpha\,.\sec\varphi'\,.\,\mathrm{A}' \\ \Delta\alpha = -\Delta\lambda\,.\sin\tfrac{1}{2}(\varphi+\varphi')\sec\tfrac{1}{2}(\Delta\varphi) - (\Delta\lambda)^3\,.\,\mathrm{F}, \end{cases}$$

hence the results for the new position

$$\begin{cases} \varphi' = \varphi + \Delta\varphi \\ \lambda' = \lambda + \Delta\lambda \\ \alpha' = \alpha + \Delta\alpha - 180^\circ \end{cases}$$

For sides not exceeding 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 $\frac{1}{2}$ ($\Delta\varphi$) and 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 $\varphi$ and $\lambda$, and $\varphi'$ and $\lambda'$ (or $\varphi$, $\varphi'$, and $\Delta\lambda$) to find $s$, $\alpha$ and $\alpha'$. This process may be used in cases where the required distance and azimuths are not implicitly contained in our table of results.

For a direct solution put

$$\begin{cases} s\,.\cos\alpha = x = -\frac{1}{\mathrm{B}}(\Delta\varphi + \mathrm{C}\,.\,y^2 + \mathrm{D}\,.\,(\Delta\varphi)^2 + \mathrm{E}\,.\,\Delta\varphi\,.\,y^2 + \mathrm{E}\,.\,\mathrm{C}\,.\,y^4) \\ s\,.\sin\alpha = y = \dfrac{\Delta\lambda\cos\varphi'}{\mathrm{A}'} \end{cases}$$

whence

$$\tan\alpha = \frac{y}{x} \text{ and } s = x\sec\alpha = y\,\mathrm{cosec}\,\alpha$$

* With slightly changed notation agreeably to more modern practice.

To facilitate finding stations an alphabetical index for each State is given, and the following subdivisions of the table have been made. There are also appended two sketches showing the triangulations of the two States.

| | No. of stations. | | No. of stations. |
|---|---|---|---|
| IN MASSACHUSETTS. | | IN MASSACHUSETTS.—Cont'd. | |
| 1. Primary stations. | 11 | 16. Massachusetts, New York, and Connecticut Boundary. | 15 |
| 2. Subordinate primaries and principal secondaries. | 20 | Connections with surrounding States. | 42 |
| 3. Nantucket and vicinity. | 30 | Total. | 1162 |
| 4. Cape Cod Bay and Peninsula. | 144 | IN RHODE ISLAND. | |
| 5. Martha's Vineyard and Vineyard Sound. | 48 | 1. Primary stations. | 1 |
| 6. Buzzard's Bay. | 65 | 2. Subordinate primaries and principal secondaries. | 12 |
| 7. Boston Bay. | 300 | 3. Sakonnet River and Mount Hope Bay. | 43 |
| 8. Cape Cod Bay to Boston Bay. | 38 | 4. Providence River. | 34 |
| 9. Coast north of Cape Ann. | 51 | 5. Narragansett Bay. | 116 |
| 10. Vicinity of Cape Ann. | 39 | 6. Rhode Island and Massachusetts Boundary. | 2 |
| 11. Vicinity of Salem. | 49 | 7. Point Judith to Knapp's Point. | 76 |
| 12. Taunton River. | 112 | Connections with surrounding States. | 30 |
| 13. Massachusetts and Rhode Island Boundary. | 22 | Total. | 314 |
| 14. Worcester and Middlesex Counties. | 10 | | |
| 15. Connecticut River Valley. | 166 | | |

*Other statistical matter:—Observers and years of observation.*

| Observer. | Year. | Observer. | Year. |
|---|---|---|---|
| MASSACHUSETTS. | | MASSACHUSETTS—Cont'd. | |
| A. D. Bache. | 1844–45–46–47, 1862. | S. C. McCorkle. | 1878. |
| F. Blake, jr. | 1877–78. | F. W. Perkins. | 1885. |
| E. Blunt. | 1843, 1862–63. | C. H. Sinclair. | 1876. |
| S. Borden. | 1832–33–34–35–36–37–38. | W. H. Stearns. | 1874. |
| C. O. Boutelle. | 1845–46–47–48–49–50–51, 1860–61, 1867 | J. A. Sullivan. | 1875. |
| C. H. Boyd. | 1868. | RHODE ISLAND. | |
| G. Bradford. | 1884. | A. D. Bache. | 1844–45. |
| T. J. Cram. | 1848–49. | E. Blunt. | 1838–39, 1843–44, 1861. |
| R. D. Cutts. | 1876–77. | S. Borden. | 1834–35–36–37. |
| C. M. Eakin. | 1845–46–47, 1849. | G. Bradford. | 1884. |
| G. A. Fairfield. | 1877. | C. Hosmer. | 1863. |
| E. Goodfellow. | 1870. | S. C. McCorkle. | 1868–69–70, 1882. |
| B. A. Gould. | 1864–65. | W. H. Stearns. | 1873. |
| A. M. Harrison. | 1876. | J. A. Sullivan. | 1871, 1874–75. |
| C. Hosmer. | 1860. | W. H. Swift. | 1835. |
| H. L. Marindin. | 1880. | | |

In Massachusetts there were formed and solved by the computers 3252 triangles (in all), of which 447 belonged to the Borden work. The number (total) of trigonometrical stations occupied is 436; of these 104 belonged to the Borden survey and 39 are common to both surveys. In Rhode Island there were formed and solved 873 triangles, 28 of which were in connection with the Borden survey. 113 trigonometrical stations were occupied in all, 6 belonging to the Borden survey, and

3 are identical in the two surveys. A number of computers were engaged upon this work, but the principal share of the work fell to Mr. E. H. Courtenay, of the Computing Division, to whose zeal, industry, and scrupulous care much of the accuracy of the results is due. The results now communicated were deduced in 1884, 1885, and part of 1886.

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 be readily deduced from

$$m = 1.25\sqrt{\frac{2}{n.\,s}}.\ \Sigma[c]$$

When $\Sigma[c]$ 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 $\pi + \varepsilon$) and to be taken with positive sign in last formula, and $t$ = number of triangles. We thus find for the adjusted triangulation of the Coast and Geodetic Survey, but *exclusive* of the primary triangulation, for Massachusetts, the value of $m = \pm 3''.7$, and for its unadjusted work $m = \pm 3''.9$; similarly for the Borden survey we find the average values $\pm 6''.0$ and $m = \pm 6''.4$ for adjusted and unadjusted work, respectively. For the Rhode Island survey, where the sides are generally short, the average value of $m$ equals $\pm 5''.1$

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 range between $\frac{1}{40\,000}$ and $\frac{1}{20\,000}$ of the length, while that of tertiary work may be estimated as low as $\frac{1}{10\,000}$ or less near its inferior limit.

There remain but a few words to be added explanatory of the table of results. Column one contains the names of the stations which are located in Massachusetts or Rhode Island, as the case may be, unless otherwise indicated; Borden stations are distinguished by the addition of his name, and stations in common bear the mark C. & G. S. and B.; columns three and five 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 six 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.= | 3.28 087 ft. | 1 ft.= | 0.304 797 m. |
| 2 | 6.56 174 | 2 | 0.609 595 |
| 3 | 9.84 261 | 3 | 0.914 392 |
| 4 | 13.12 348 | 4 | 1.219 189 |
| 5 | 16.40 435 | 5 | 1.523 986 |
| 6 | 19.68 522 | 6 | 1.828 784 |
| 7 | 22.96 609 | 7 | 2.133 581 |
| 8 | 26.24 695 | 8 | 2.438 378 |
| 9 | 29.52 782 | 9 | 2.743 175 |
| 10 | 32.80 869 | 10 | 3.047 973 |

or the logarithm factors may be used, viz.: log 3.2808693 = 0.5159889
and log 0.30479727 = $\bar{9}$.4840111

To convert metres into statute miles, we have:

| | |
|---|---|
| 1 m. = | 0.000 621 38 st. mls. |
| 2 | 0.001 242 75 |
| 3 | 0.001 864 13 |
| 4 | 0.002 485 51 |
| 5 | 0.003 106 88 |
| 6 | 0.003 728 26 |
| 7 | 0.004 349 64 |
| 8 | 0.004 971 01 |
| 9 | 0.005 592 39 |
| 10 | 0.006 213 77 |

also log 0.000621376767 = $\bar{6}$.7933550

COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE,
*April* 16, 1886.

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*Index of stations in Massachusetts.*

*Index of stations in Massachusetts.—Continued.*

*Index of stations in Massachusetts.—Continued.*

*Index of stations in Massachusetts.—Continued.*

*Index of stations in Massachusetts.—Continued.*

*Index of stations in Massachusetts.—Continued.*

*Index of stations in Massachusetts.—Continued.*

*Index of stations in Massachusetts.—Continued.*

*Index of stations in Massachusetts.—Continued.*

*Index of stations in Massachusetts.—Continued.*

*Index of stations in Massachusetts.—Continued.*

*Index of stations in Massachusetts.—Continued.*

*Index of stations in Massachusetts.—Continued.*

*Index of stations in Massachusetts.—Continued.*

# TABLE OF GEOGRAPHICAL POSITIONS

DETERMINED IN THE

# STATE OF MASSACHUSETTS

AND

## CONNECTIONS WITH STATIONS IN SURROUNDING STATES.

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### TRIANGULATIONS OF 1832-1885.

**PRIMARY STATIONS.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Agamenticus, Me., astronomical azimuth and latitude station, 1847. | 43 13 24.630 | 760.1 | 70 41 32.907 | 742.6 |
| Thompson, astronomical azimuth and latitude station, 1846. | 42 36 41.924 | 1293.6 | 70 43 49.164 | 1120.4 |
| Unkonoonuc, N. H., astronomical azimuth and latitude station, 1848. | 42 58 59.864 | 1847.4 | 71 35 19.380 | 439.0 |
| Blue Hill, astronomical azimuth station, 1845. | 42 12 43.941 | 1355.7 | 71 06 52.638 | 1207.3 |
| Wachusett, astronomical azimuth and latitude station, 1860 (C. & G. S. & B.). | 42 29 20.784 | 641.4 | 71 53 13.984 | 319.4 |
| Monadnock, N. H. | 42 51 41.174 | 1270.6 | 72 06 30.776 | 698.6 |
| Mount Tom, astronomical azimuth and latitude station, 1862. | 42 14 30.798 | 950.2 | 72 38 55.056 | 1262.1 |
| Bald Hill (Tolland County), Conn. | 41 58 25.890 | 798.9 | 72 11 55.027 | 1266.9 |
| Box Hill, Conn. | 41 47 59.794 | 1844.9 | 72 27 21.404 | 494.1 |
| Sandford, Conn., astronomical azimuth and latitude station, 1862. | 41 27 42.801 | 1320.4 | 72 56 59.304 | 1376.0 |
| Ivy, Conn. | 41 52 18.500 | 570.7 | 73 13 27.926 | 644.0 |
| Beaconpole, R. I., astronomical azimuth station, 1844. | 41 59 42.468 | 1310.2 | 71 27 01.257 | 28.9 |
| Great Meadow (C. & G. S. & B.). | 41 52 45.138 | 1392.7 | 71 13 02.292 | 52.9 |
| Copecut, astronomical azimuth station, 1844 (C. & G. S. & B.). | 41 43 17.245 | 532.1 | 71 03 36.644 | 847.1 |
| Massachusetts North Base, 1844. | 42 03 06.592 | 203.4 | 71 12 24.871 | 572.0 |
| Massachusetts South Base, 1844. | 41 54 49.921 | 1540.3 | 71 18 16.114 | 371.3 |
| Manomet, astronomical latitude station, 1867 (C. & G. S. & B.). | 41 55 38.699 | 1194.0 | 70 35 28.128 | 648.1 |
| Greylock or Saddle Mountain. | 42 38 14.088 | 434.6 | 73 09 59.130 | 1347.2 |
| Mount Equinox, Vt. | 43 09 57.980 | 1789.2 | 73 07 02.708 | 61.2 |
| Mount Rafinesque, N. Y. | 42 47 21.155 | 652.9 | 73 36 58.818 | 1336.8 |
| Perry's Peak (C. & G. S. & B.). | 42 25 15.648 | 482.8 | 73 22 48.781 | 1115.3 |
| Yellow Pine, N. Y. | 42 29 28.727 | 886.4 | 73 40 27.902 | 637.3 |
| Helderberg, N. Y. | 42 37 39.072 | 1205.7 | 74 00 38.487 | 877.0 |
| Prospect, N. Y. | 43 25 17.949 | 554.0 | 73 46 04.570 | 102.8 |

## PRIMARY STATIONS.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 182 35 25.476 | 2 36 58.261 | Agamenticus | 68041.91 | 4.8327765 |
| 249 36 12.618 | 70 12 57.351 | Agamenticus | 77686.65 | 4.8903464 |
| 300 09 32.872 | 120 44 32.424 | Thompson. | 81461.91 | 4.9109546 |
| 155 43 45.770 | 335 24 30.537 | Unkonqonuc | 94078.56 | 4.9734907 |
| 215 21 29.380 | 35 37 02.480 | Thompson. | 54491.94 | 4.7363323 |
| 203 54 04.099 | 24 06 13.358 | Unkonoonuc | 60093.82 | 4.7788298 |
| 295 31 38.891 | 116 02 52.610 | Blue Hill | 70700.04 | 4.8494197 |
| 336 14 24.474 | 156 23 24.577 | Wachusett | 45164.53 | 4.6547975 |
| 252 07 57.590 | 72 29 12.028 | Unkonoonuc. | 44548.68 | 4.6488348 |
| 246 05 57.988 | 66 36 45.098 | Wachusett | 68470.37 | 4.8355027 |
| 212 37 17.232 | 32 59 12.085 | Monadnock. | 81877.61 | 4.9131652 |
| 128 48 17.330 | 308 30 11.049 | Mount Tom | 47662.88 | 4.6781803 |
| 204 05 01.004 | 24 17 34.496 | Wachusett. | 62740.03 | 4.7975447 |
| 162 03 16.319 | 341 55 31.984 | Mount Tom | 51616.87 | 4.7127917 |
| 227 47 14.069 | 47 57 32.578 | Bald Hill. | 28797.56 | 4.4593557 |
| 227 27 39.231 | 47 47 20.351 | Box Hill | 55707.02 | 4.7459099 |
| 196 00 11.934 | 16 12 15.370 | Mount Tom. | 90171.62 | 4.9550699 |
| 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 |
| 146 50 05.792 | 326 32 28.490 | Wachusett | 65656.70 | 4.8172790 |
| 228 55 19.774 | 49 08 50.124 | Blue Hill. | 36777.41 | 4.5655811 |
| 123 44 56.597 | 303 35 35.905 | Beaconpole | 23223.72 | 4.3659318 |
| 192 54 36.214 | 12 58 43.781 | Blue Hill. | 37951.70 | 4.5792312 |
| 133 18 14.851 | 313 02 37.562 | Beaconpole | 44425.23 | 4.6476297 |
| 175 17 06.299 | 355 14 55.237 | Blue Hill. | 54694.51 | 4.7379437 |
| 2 34 36.135 | 182 34 11.112 | Great Meadow | 19193.11 | 4.2831454 |
| 72 44 05.443 | 252 34 18.759 | Beaconpole. | 21123.09 | 4.3247575 |
| 207 47 11.966 | 27 51 06.916 | Mass. North Base | 17326.376 | 4.2387077 |
| 126 46 54.940 | 306 41 03.861 | Beaconpole. | 15091.32 | 4.1787273 |
| 59 44 30.308 | 239 25 44.316 | Copecut | 45185.59 | 4.6550000 |
| 126 18 34.859 | 305 57 32.162 | Blue Hill. | 53642.95 | 4.7295127 |
| 253 35 57.679 | 74 19 02.804 | Monadnock | 90121.17 | 4.9548268 |
| 315 41 37.385 | 136 02 35.298 | Mount Tom. | 61186.51 | 4.7866557 |
| 292 01 23.100 | 112 42 40.752 | Monadnock | 88939.22 | 4.9490933 |
| 3 54 40.434 | 183 52 50.335 | Greylock. | 58886.79 | 4.7700179 |
| 224 01 02.231 | 44 21 26.671 | Mount Equinox | 58390.01 | 4.7663386 |
| 294 27 18.781 | 114 45 37.465 | Greylock. | 40539.34 | 4.6078766 |
| 154 43 48.875 | 334 34 13.448 | Mount Rafinesque | 45258.32 | 4.6556985 |
| 216 06 22.198 | 36 15 02.456 | Greylock. | 29757.38 | 4.4735946 |
| 188 10 18.052 | 8 12 39.685 | Mount Rafinesque | 33432.70 | 4.5241714 |
| 287 47 03.641 | 107 58 58.575 | Perry's Peak. | 25429.20 | 4.4053327 |
| 240 47 42.718 | 61 03 45.635 | Mount Rafinesque | 36965.44 | 4.5677959 |
| 268 49 12.873 | 89 23 31.424 | Greylock. | 69261.34 | 4.8404909 |
| 298 02 50.279 | 118 29 36.200 | Mount Equinox | 59941.35 | 4.7777265 |
| 349 59 10.459 | 170 05 23.401 | Mount Rafinesque. | 71335.75 | 4.8533073 |

**SECONDARY STATIONS.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Patuccawa, N. H. | 43 07 13.689 | 422.5 | 71 11 51.318 | 1160.1 |
| Isles of Shoals, N. H., astronomical latitude station, 1847. | 42 59 14.862 | 458.6 | 70 36 50.285 | 1139.2 |
| Hampton Falls, N. H. | 42 54 44.372 | 1369.2 | 70 53 51.877 | 1176.7 |
| Holt (C. & G. S. & B.). | 42 38 28.026 | 864.8 | 71 06 24.872 | 566.7 |
| Powow. | 42 51 57.006 | 1758.9 | 70 56 18.812 | 427.0 |
| Orne. | 42 30 10.264 | 316.7 | 70 57 54.451 | 1243.1 |
| Prospect Rowley (C. & G. S. & B.). | 42 42 19.154 | 591.0 | 70 53 33.128 | 754.0 |
| Prospect Waltham (C. & G. S. & B.). | 42 23 18.831 | 581.0 | 71 15 15.333 | 350.7 |
| Powderhorn. | 42 24 04.683 | 144.5 | 71 01 52.006 | 1189.3 |
| Cambridge Observatory, center of dome. Telegraphic longitude station, 1851 and 1872. | 42 22 53.490 | 1650.6 | 71 07 43.885 | 1003.9 |
| Corey. | 42 20 33.376 | 1029.9 | 71 08 02.199 | 50.3 |
| Nantasket. | 42 18 15.690 | 484.1 | 70 54 20.203 | 462.8 |
| Indian, astronomical azimuth station, 1845 (C. & G. S. & B.). | 41 25 46.744 | 1442.0 | 70 40 40.699 | 945.0 |
| Shootflying, astronomical azimuth station, 1845. | 41 41 07.334 | 226.2 | 70 20 49.738 | 1150.3 |
| Nantucket Cliff. | 41 17 35.813 | 1104.8 | 70 06 53.793 | 1251.6 |
| Sampson. | 41 22 41.830 | 1290.4 | 70 29 02.471 | 57.4 |
| Hyannis (C. & G. S. & B.). | 41 37 53.339 | 1645.5 | 70 18 26.666 | 617.3 |
| Nantucket (Great Point) light-house, 1835–'75 (C. & G. S. & B.). | 41 23 24.345 | 751.1 | 70 02 46.056 | 1070.0 |
| Cape Poge light-house, 1845–'75. | 41 25 16.028 | 494.5 | 70 27 05.704 | 132.4 |
| Spencer, R. I., astronomical azimuth station, 1844. | 41 40 43.256 | 1334.4 | 71 29 40.685 | 941.0 |
| Quaker, R. I. (C. & G. S. & B.). | 41 34 57.376 | 1770.1 | 71 15 18.337 | 424.7 |
| Pocasset, R. I. (C. & G. S. & B.). | 41 39 09.420 | 290.6 | 71 11 32.364 | 748.9 |
| Cuttyhunk (C. & G. S. & B.). | 41 25 14.887 | 459.3 | 70 56 02.646 | 61.4 |

**SECONDARY STATIONS.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | Metres. | |
| 254 15 15.37 | 74 35 59.52 | Agamenticus | 42638.85 | 4.6298055 |
| 64 34 34.63 | 244 18 33.40 | Unkonoonuc. | 35323.24 | 4.5480605 |
| 12 53 01.04 | 192 48 16.44 | Thompson | 42819.83 | 4.6316450 |
| 166 19 50.29 | 346 16 37.16 | Agamenticus. | 26990.73 | 4.4312146 |
| 205 44 26.82 | 25 52 51.44 | Agamenticus | 38401.12 | 4.5843439 |
| 133 30 41.93 | 313 18 25.53 | Patuccawa. | 33647.75 | 4.5269560 |
| 0 45 57.22 | 180 45 38.49 | Blue Hill | 47647.90 | 4.6780438 |
| 275 55 18.82 | 96 10 36.93 | Thompson. | 31066.38 | 4.4922906 |
| 328 48 07.28 | 148 56 36.04 | Thompson | 32986.27 | 4.5183332 |
| 28 57 40.16 | 208 50 48.74 | Holt. | 28515.06 | 4.4550743 |
| 142 53 16.06 | 322 47 30.75 | Holt | 19272.40 | 4.2849357 |
| 237 50 41.09 | 58 00 12.78 | Thompson. | 22757.45 | 4.3571235 |
| 307 59 01.76 | 128 05 37.47 | Thompson | 16887.32 | 4.2275607 |
| 14 51 34.25 | 194 48 37.35 | Orne. | 23266.58 | 4.3667326 |
| 329 30 20.54 | 149 35 58.86 | Blue Hill | 22723.08 | 4.3564673 |
| 20 24 11.44 | 200 16 17.33 | Beaconpole. | 46606.15 | 4.6684432 |
| 85 40 19.75 | 265 31 18.12 | Prospect Waltham | 18427.94 | 4.2654767 |
| 18 10 41.64 | 198 07 19.29 | Blue Hill. | 22104.06 | 4.3444721 |
| 94 22 19.77 | 274 17 15.44 | Prospect Waltham | 10356.65 | 4.0152191 |
| 356 25 24.69 | 176 25 59.18 | Blue Hill. | 18844.17 | 4.2751770 |
| 232 22 39.62 | 52 26 49.11 | Powderhorn | 10688.86 | 4.0289312 |
| 117 17 35.42 | 297 12 43.55 | Prospect Waltham. | 11148.73 | 4.0472255 |
| 59 22 52.32 | 239 14 26.33 | Blue Hill | 20055.70 | 4.3022378 |
| 156 11 49.30 | 336 03 39.97 | Holt. | 40906.81 | 4.6117956 |
| 187 25 18.24 | 7 28 46.08 | Manomet | 55755.26 | 4.7462858 |
| 135 36 04.33 | 315 20 51.24 | Copecut. | 45458.21 | 4.6576123 |
| 44 17 20.61 | 224 04 10.56 | Indian | 39601.75 | 4.5977144 |
| 143 03 20.31 | 322 53 34.76 | Manomet. | 33673.18 | 4.5272841 |
| 156 04 20.29 | 335 55 06.49 | Shootflying | 47668.76 | 4.6782338 |
| 108 00 24.87 | 287 38 05.47 | Indian. | 49486.52 | 4.6944869 |
| 286 52 09.96 | 107 06 47.50 | Nantucket Cliff | 32305.24 | 4.5092730 |
| 109 26 33.38 | 289 18 51.59 | Indian. | 17192.59 | 4.2353414 |
| 151 03 58.99 | 331 02 23.89 | Shootflying | 6839.50 | 3.8350247 |
| 27 43 48.12 | 207 36 46.78 | Sampson. | 31752.19 | 4.5017737 |
| 28 12 03.52 | 208 09 19.88 | Nantucket Cliff | 12197.72 | 4.0862788 |
| 142 38 50.92 | 322 26 52.32 | Shootflying. | 41309.46 | 4.6160495 |
| 92 56 29.40 | 272 47 30.16 | Indian | 18948.38 | 4.2775721 |
| 207 12 12.72 | 27 17 56.82 | Hyannis. | 26280.49 | 4.4196335 |
| 185 57 36.34 | 5 59 22.68 | Beaconpole | 35339.35 | 4.5482586 |
| 262 22 17.91 | 82 39 38.36 | Copecut. | 36475.19 | 4.5619976 |
| 226 24 37.79 | 46 32 24.14 | Copecut | 22393.41 | 4.3501202 |
| 118 12 27.73 | 298 02 54.85 | Spencer. | 22634.29 | 4.3547668 |
| 150 41 04.12 | 330 30 44.69 | Beaconpole | 43666.53 | 4.6401487 |
| 235 09 32.46 | 55 14 48.84 | Copecut. | 13397.89 | 4.1270365 |
| 123 56 41.52 | 303 43 55.71 | Quaker | 32270.72 | 4.5088086 |
| 162 33 26.03 | 342 28 24.78 | Copecut. | 35009.26 | 4.5441829 |

**SECONDARY STATIONS**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Nootas. | 41 32 13.020 | 401.6 | 71 07 25.832 | 598.8 |
| East Rock, R. I. | 41 27 04.650 | 143.4 | 71 11 38.340 | 889.9 |
| Mount Hope, R. I. | 41 40 26.130 | 806.1 | 71 14 26.209 | 606.2 |
| McSparran, R. I. | 41 29 46.953 | 1448.5 | 71 27 24.737 | 573.7 |
| French's Hill (C. & G. S. & B.) | 42 25 38.470 | 1187.0 | 73 02 16.447 | 375.9 |
| Bald Peak (or Mount Washington or Mount Everett or Taughanuc Mount or Dome Peak), (C. & G. S. & B.). | 42 06 07.301 | 225.3 | 73 25 59.109 | 1358.2 |

**COAST NORTH OF CAPE ANN.**

| Station. | Latitude. | Seconds in metres. | Longitude | Seconds in metres. |
|---|---|---|---|---|
| Great Boar's Head, N. H. | 42 55 05.432 | 167.6 | 70 47 45.932 | 1041.8 |
| Seabrook, N. H. | 42 52 29.586 | 913.0 | 70 49 06.554 | 148.8 |
| Old Town. | 42 46 07.582 | 234.0 | 70 51 00.902 | 20.5 |
| Crane Neck. | 42 46 13.667 | 421.8 | 70 58 31.748 | 721.8 |
| Tilton. | 42 40 53.162 | 1640.4 | 70 47 34.478 | 784.9 |
| Hampton, N. H. | 42 56 33.94 | 1047.3 | 70 49 37.92 | 859.8 |
| Batt's Hill. | 42 52 15.86 | 489.5 | 70 53 32.60 | 739.9 |
| Powow (Borden). | 42 51 57.08 | 1761.3 | 70 56 18.76 | 425.9 |
| Amesbury Mills, tall white spire. | 42 51 21.38 | 659.8 | 70 55 58.58 | 1329.9 |
| Bartlett. | 42 50 04.46 | 137.6 | 70 55 23.74 | 539.2 |
| Salisbury Beach. | 42 50 49.10 | 1515.1 | 70 49 03.44 | 78.1 |
| Salisbury Marsh. | 42 51 06.88 | 212.3 | 70 50 11.66 | 264.7 |
| Salisbury Marsh (Borden). | 42 52 18.68 | 576.4 | 70 49 14.68 | 333.2 |
| Salisbury church. | 42 50 33.98 | 1048.6 | 70 51 38.96 | 884.7 |
| West Salisbury, powder-house. | 42 51 22.08 | 681.4 | 70 54 51.36 | 1166.0 |

**SECONDARY STATIONS—Continued.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 309 04 33.44 | 129 12 05.94 | Cuttyhunk | 20436.54 | 4.3104073 |
| 156 03 33.63 | 336 00 49.97 | Pocasset. | 14058.13 | 4.1479275 |
| 160 44 27.59 | 340 42 01.77 | Quaker | 15450.37 | 4.1889388 |
| 278 46 25.33 | 98 56 44.56 | Cuttyhunk. | 21986.15 | 4.3421491 |
| 6 47 22.05 | 186 46 47.42 | Quaker | 10213.98 | 4.0091950 |
| 300 27 25.96 | 120 29 21.52 | Pocasset. | 4666.63 | 3.6690033 |
| 171 10 21.59 | 351 08 51.35 | Spencer | 20491.06 | 4.3115644 |
| 240 18 12.34 | 60 26 14.04 | Quaker. | 19370.85 | 4.2871487 |
| 155 40 41.39 | 335 35 28.62 | Greylock | 25595.11 | 4.4081569 |
| 88 41 00.95 | 268 27 09.60 | Perry's Peak. | 28181.49 | 4.4499639 |
| 155 21 59.47 | 335 12 14.80 | Yellow Pine | 47600.92 | 4.6776154 |
| 187 00 04.08 | 7 02 12.09 | Perry's Peak. | 35699.39 | 4.5526608 |

**COAST NORTH OF CAPE ANN.**

| | | | | |
|---|---|---|---|---|
| 193 56 11.7 | 14 00 26.5 | Agamenticus | 34954.4 | 4.543502 |
| 242 33 32.4 | 62 40 59.1 | Isles of Shoals. | 16737.2 | 4.223682 |
| 233 05 42.0 | 53 14 03.5 | Isles of Shoals | 20860.3 | 4.319320 |
| 84 11 25.5 | 264 06 31.4 | Powow. | 9863.0 | 3.994007 |
| 26 10 38.5 | 206 08 55.2 | Prospect Rowley | 7853.3 | 3.895050 |
| 146 12 55.1 | 326 09 19.0 | Powow. | 12977.7 | 4.113199 |
| 316 47 00.5 | 136 50 23.1 | Prospect Rowley | 9925.0 | 3.996732 |
| 195 53 51.7 | 15 55 22.0 | Powow. | 11016.7 | 4.042051 |
| 296 29 39.7 | 116 35 29.4 | Railcut | 13139.7 | 4.118587 |
| 326 28 15.6 | 146 30 48.2 | Thompson. | 9297.5 | 3.968368 |
| 317 04 32 | 137 05 48 | Great Boar's Head | 3729.9 | 3.57170 |
| 59 36 12 | 239 33 19 | Hampton Falls. | 6677.5 | 3.82468 |
| 174 32 49 | 354 32 36 | Hampton Falls | 4603.8 | 3.66312 |
| 81 15 08 | 261 13 15 | Powow. | 3817.5 | 3.58178 |
| 317 59 17 | 138 11 03 | Railcut | 35420.8 | 4.549258 |
| 348 03 49 | 168 05 42 | Prospect Rowley. | 18226.7 | 4.260709 |
| 325 02 26 | 145 05 48 | Old Town | 11811.4 | 4.07230 |
| 348 48 32 | 168 50 11 | Prospect Rowley. | 17055.3 | 4.23186 |
| 320 43 14 | 140 46 13 | Old Town | 9439.5 | 3.97495 |
| 30 58 23 | 210 56 15 | Crane Neck. | 8304.8 | 3.91933 |
| 178 42 06 | 358 42 04 | Seabrook | 3101.8 | 3.49162 |
| 102 00 42 | 281 55 46 | Powow. | 10104.2 | 4.00450 |
| 210 04 18 | 30 05 02 | Seabrook | 2949.2 | 3.46970 |
| 289 30 46 | 109 31 32 | Salisbury Beach. | 1643.1 | 3.21567 |
| 332 31 48 | 152 38 46 | Railcut | 30443.5 | 4.483494 |
| 17 38 24 | 197 35 29 | Prospect Rowley. | 19410.3 | 4.288032 |
| 353 59 33 | 173 59 59 | Old Town | 8265.9 | 3.91729 |
| 111 59 08 | 291 55 58 | Powow. | 6850.3 | 3.83571 |
| 118 30 16 | 298 29 17 | Powow | 2258.9 | 3.35390 |
| 192 11 45 | 12 12 25 | Hampton Falls. | 6386.8 | 3.80528 |

**COAST NORTH OF CAPE ANN**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| West Salisbury, church. | 42 50 39.64 | 1223.3 | 70 55 01.21 | 231.8 |
| Brandybrow (Borden), N. H. | 42 50 00.04 | 1.2 | 71 03 16.19 | 367.7 |
| Morrill. | 42 49 15.65 | 483.0 | 70 51 06.50 | 147.6 |
| Mouth of Merrimac, chimney of house. | 42 49 13.63 | 420.7 | 70 49 18.14 | 412.0 |
| Newbury, Belleville church. | 42 49 06.77 | 208.9 | 70 53 24.84 | 564.3 |
| Newbury, Upper Green church. | 42 47 58.56 | 1807.1 | 70 51 46.19 | 1050.5 |
| Newburyport, Pleasant street Unitarian church. | 42 48 38.42 | 1185.6 | 70 52 19.21 | 436.4 |
| Newburyport, Harris street church. | 42 48 31.71 | 978.6 | 70 52 23.74 | 539.4 |
| Newburyport, Federal street church. | 42 48 30.56 | 943.1 | 70 51 59.57 | 1353.4 |
| Newburyport Academy. | 42 48 31.79 | 981.1 | 70 52 28.89 | 656.4 |
| Newburyport, beacon on north pier. | 42 48 49.26 | 1520.1 | 70 51 28.43 | 645.9 |
| Newburyport light-house (Borden), 1834. | 42 48 28.98 | 894.3 | 70 48 48.39 | 1099.5 |
| Newburyport, east light-house, 1850–'51. | 42 48 26.93 | 831.0 | 70 49 01.34 | 30.4 |
| Newburyport, west light-house, 1850'–51. | 42 48 26.90 | 830.0 | 70 49 06.92 | 157.2 |
| Newburyport light-house, 1878. | 42 48 54.76 | 1689.8 | 70 49 10.42 | 236.7 |
| Upper Harbor, inner beacon, 1878. | 42 48 40.70 | 1255.9 | 70 51 59.70 | 1356.2 |
| Upper Harbor, outer beacon, 1878. | 42 48 41.70 | 1286.8 | 70 51 55.25 | 1255.2 |
| Bailey's wharf. | 42 48 42.94 | 1325.0 | 70 51 56.55 | 1284.7 |
| Ayer's Hill (Borden). | 42 48 23.28 | 718.4 | 71 03 27.81 | 631.9 |
| Indian Hill, flagstaff, 1878. | 42 47 03.22 | 99.4 | 70 56 54.40 | 1236.4 |
| Thompson's Hotel. | 42 47 57.15 | 1763.6 | 70 48 48.56 | 1103.4 |
| Old Town church spire. | 42 47 58.49 | 1804.9 | 70 51 46.19 | 1049.5 |
| Plum Island magnetic station. | 42 47 59.94 | 1849.7 | 70 48 49.34 | 1121.1 |

**COAST NORTH OF CAPE ANN.**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 25 15 22 | 205 15 07 | Bartlett | 1200.0 | 3.07918 |
| 143 35 01 | 323 34 08 | Powow. | 2966.9 | 3.47231 |
| 11 22 53 | 191 20 45 | Holt | 21780.3 | 4.338064 |
| 5 03 15 | 185 03 12 | Ayer's Hill. | 2996.7 | 3.476642 |
| 358 44 26 | 178 44 30 | Old Town | 5804.8 | 3.76379 |
| 125 06 07 | 305 02 35 | Powow. | 8665.2 | 3.93778 |
| 22 08 37 | 202 07 27 | Old Town | 6197.8 | 3.79224 |
| 117 51 47 | 297 47 01 | Powow. | 10801.4 | 4.03348 |
| 52 35 04 | 232 31 36 | Crane Neck | 8785.4 | 3.94376 |
| 143 04 17 | 323 02 19 | Powow. | 6573.1 | 3.81777 |
| 70 41 32 | 250 36 57 | Crane Neck | 9769.7 | 3.98988 |
| 139 56 46 | 319 53 41 | Powow. | 9616.6 | 3.98302 |
| 8 10 47 | 188 09 57 | Prospect Rowley | 11823.3 | 4.07274 |
| 62 13 10 | 242 08 57 | Crane Neck. | 9572.8 | 3.98104 |
| 63 02 46 | 242 58 36 | Crane Neck | 9386.2 | 3.97249 |
| 337 02 47 | 157 03 43 | Old Town. | 4829.5 | 3.68390 |
| 167 32 48 | 347 31 32 | Hampton Falls | 11813.5 | 4.07238 |
| 205 16 05 | 25 18 58 | Great Boar's Head. | 13476.9 | 4.12959 |
| 170 42 05 | 350 41 09 | Hampton Falls | 11650.4 | 4.06634 |
| 207 50 37 | 27 53 49 | Great Boar's Head. | 13740.7 | 4.13801 |
| 352 50 58 | 172 51 17 | Old Town | 5027.9 | 3.70139 |
| 131 19 43 | 311 16 26 | Powow. | 8777.7 | 3.94338 |
| 325 59 24 | 146 06 04 | Railcut | 24035.6 | 4.380855 |
| 29 35 49 | 209 32 36 | Prospect Rowley. | 13120.8 | 4.117961 |
| 32 18 10 | 212 16 49 | Old Town | 5086.5 | 3.70642 |
| 123 09 53 | 303 04 55 | Powow. | 11862.6 | 4.07418 |
| 31 04 59 | 211 03 42 | Old Town | 5019.3 | 3.70064 |
| 123 30 20 | 303 25 26 | Powow. | 11757.4 | 4.07031 |
| 25 57 49 | 205 56 34 | Old Town | 5737.3 | 3.75871 |
| 120 04 20 | 299 59 29 | Powow. | 11237.0 | 4.05065 |
| 135 51 21 | 315 48 25 | Powow | 8445.2 | 3.92661 |
| 228 14 48 | 48 15 24 | Morrill. | 1619.8 | 3.20945 |
| 73 07 48 | 253 07 45 | Upper Harbor, inner beacon | 105.5 | 2.02338 |
| 226 34 43 | 46 35 16 | Morrill. | 1524.5 | 3.18314 |
| 46 00 06 | 226 00 04 | Upper Harbor, inner beacon | 99.4 | 1.99760 |
| 322 33 14 | 142 33 15 | Upper Harbor, outer beacon. | 48.4 | 1.68518 |
| 309 39 56 | 129 46 40 | Prospect Rowley | 17581.9 | 4.245066 |
| 12 23 13 | 192 21 13 | Holt. | 18804.4 | 4.274260 |
| 282 01 28 | 102 05 28 | Old Town | 8217.5 | 3.91474 |
| 185 05 33 | 5 05 57 | Powow. | 9101.9 | 3.95913 |
| 41 40 13 | 221 38 43 | Old Town | 4525.4 | 3.65566 |
| 125 56 23 | 305 51 17 | Powow. | 12623.5 | 4.10118 |
| 190 21 38 | 10 23 05 | Hampton | 16170.4 | 4.20872 |
| 202 28 08 | 22 30 51 | Great Boar's Head. | 14258.7 | 4.15408 |
| 40 47 12 | 220 45 43 | Old Town | 4578.7 | 3.66074 |
| 125 40 04 | 305 34 58 | Powow. | 12558.8 | 4.09895 |

**COAST NORTH OF CAPE ANN**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Plum Island 1. | 42 46 37.02 | 1142.4 | 70 48 17.72 | 402.8 |
| Plum Island 2. | 42 44 27.80 | 857.8 | 70 47 33.78 | 768.4 |
| Little Old Town. | 42 46 24.87 | 767.4 | 70 50 32.24 | 732.9 |
| Dummer Academy. | 42 45 16.29 | 502.7 | 70 53 59.58 | 1354.9 |
| Wood's Hotel. | 42 45 23.87 | 736.6 | 70 48 15.60 | 354.7 |
| Poplar Hill (Borden). | 42 44 06.22 | 191.9 | 71 15 22.10 | 502.7 |
| Poplar Hill, stone monument (Borden). | 42 44 11.56 | 356.7 | 71 15 20.30 | 461.8 |
| Ox Pasture Hill. | 42 44 17.08 | 527.0 | 70 52 55.00 | 1251.1 |
| Rowley Marsh. | 42 44 37.76 | 1165.2 | 70 50 16.33 | 371.4 |
| Rowley church spire with turrets. | 42 42 59.02 | 1821.2 | 70 52 42.38 | 964.2 |
| Byfield church, square tower. | 42 44 19.04 | 587.5 | 70 55 53.81 | 1224.0 |
| Gumpus (Borden), N. H. | 42 43 32.91 | 1015.5 | 71 21 46.61 | 1060.5 |
| Ipswich Town Farm. | 42 43 03.92 | 121.0 | 70 50 52.09 | 1185.3 |
| Proctor's barn. | 42 43 02.03 | 62.6 | 70 46 51.52 | 1172.3 |
| Manning's Hill. | 42 42 30.26 | 933.8 | 70 48 23.32 | 530.6 |
| Lowell church (Borden). | 42 38 48.03 | 1482.0 | 71 19 06.70 | 152.6 |
| Marsh & Jones (Borden). | 42 42 43.81 | 1351.9 | 71 18 11.19 | 254.6 |
| Pine Tree Boundary, stone monument (Borden). | 42 41 50.26 | 1550.9 | 71 19 22.02 | 501.2 |

**VICINITY OF CAPE ANN.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| Railcut (C. & G. S. & B). | 42 37 42.872 | 1322.7 | 70 38 58.400 | 1330.6 |
| Poole's Hill. | 42 39 24.690 | 762.0 | 70 38 05.772 | 131.6 |
| Andrews' Point. | 42 40 58.98 | 1819.9 | 70 37 46.80 | 1065.4 |
| Lane's Cove, white spire. | 42 40 41.55 | 1282.1 | 70 39 15.88 | 361.5 |

**COAST NORTH OF CAPE ANN**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 354 42 01 | 174 42 30 | Tilton | 10655.9 | 4.02759 |
| 76 15 24 | 256 13 33 | Old Town. | 3819.1 | 3.58196 |
| 0 08 24 | 180 08 24 | Tilton | 6623.4 | 3.82108 |
| 64 08 09 | 244 04 05 | Prospect Rowley. | 9088.7 | 3.95850 |
| 88 13 40 | 268 08 14 | Crane Neck | 10906.9 | 4.03770 |
| 50 42 39 | 230 42 20 | Old Town. | 842.1 | 2.92536 |
| 105 59 33 | 285 56 28 | Crane Neck | 6437.1 | 3.80869 |
| 353 42 48 | 173 43 06 | Prospect Rowley. | 5499.0 | 3.74028 |
| 353 36 21 | 173 36 49 | Tilton | 8405.4 | 3.92456 |
| 51 45 19 | 231 41 44 | Prospect Rowley. | 9201.5 | 3.96386 |
| 310 25 20 | 130 31 25 | Holt | 16077.5 | 4.206219 |
| 243 53 52 | 64 01 57 | Ayer's Hill. | 18072.9 | 4.257029 |
| 13 57 38 | 193 57 37 | Poplar Hill | 169.6 | 2.22936 |
| 115 11 39 | 295 07 50 | Crane Neck | 8461.0 | 3.92742 |
| 13 24 47 | 193 24 21 | Prospect Rowley. | 3740.8 | 3.57296 |
| 331 59 52 | 152 01 42 | Tilton | 7848.4 | 3.89478 |
| 46 19 49 | 226 17 35 | Prospect Rowley. | 6192.1 | 3.79184 |
| 298 57 47 | 119 01 16 | Tilton | 8012.2 | 3.90375 |
| 43 12 04 | 223 11 30 | Prospect Rowley. | 1687.3 | 3.22720 |
| 243 16 39 | 63 19 58 | Old Town | 7455.9 | 3.87250 |
| 319 07 10 | 139 08 45 | Prospect Rowley. | 4891.8 | 3.68947 |
| 250 09 53 | 70 22 19 | Ayer's Hill | 26540.4 | 4.423908 |
| 294 03 36 | 114 14 01 | Holt. | 22998.5 | 4.361700 |
| 177 58 34 | 357 58 28 | Old Town | 5670.7 | 3.75364 |
| 69 21 42 | 249 19 53 | Prospect Rowley. | 3916.3 | 3.59288 |
| 81 47 59 | 261 43 27 | Prospect Rowley | 9234.9 | 3.96543 |
| 135 17 28 | 315 14 39 | Old Town. | 8059.5 | 3.90631 |
| 339 38 26 | 159 38 59 | Tilton | 3196.1 | 3.50462 |
| 87 14 38 | 267 11 08 | Prospect Rowley. | 7059.1 | 3.84875 |
| 157 31 24 | 337 29 36 | Gumpus | 9514.5 | 3.978387 |
| 271 57 58 | 92 06 34 | Holt. | 17365.8 | 4.239695 |
| 107 11 57 | 287 09 31 | Gumpus | 5130.2 | 3.71014 |
| 9 51 48 | 189 51 10 | Lowell church. | 7384.6 | 3.86833 |
| 133 55 29 | 313 53 51 | Gumpus | 4567.2 | 3.65965 |
| 224 16 58 | 44 17 46 | Marsh & Jones. | 2308.3 | 3.36328 |

**VICINITY OF CAPE ANN.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| 74 10 58.4 | 254 07 41.5 | Thompson | 6888.2 | 3.838105 |
| 113 15 06.7 | 293 05 13.9 | Prospect Rowley. | 21667.7 | 4.335812 |
| 20 53 33.8 | 200 52 58.1 | Railcut | 3362.8 | 3.526702 |
| 57 20 06.2 | 237 16 13.6 | Thompson. | 9297.4 | 3.968362 |
| 117 52 03 | 297 43 04 | Old Town | 20422.6 | 4.31011 |
| 89 17 09 | 269 10 31 | Tilton. | 13380.8 | 4.12648 |
| 40 07 29 | 220 04 24 | Thompson | 9666.4 | 3.98526 |
| 91 51 18 | 271 45 40 | Tilton. | 11358.0 | 4.05530 |

VICINITY OF CAPE ANN—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Choate. | 42 39 55.52 | 1713.2 | 70 45 40.80 | 929.1 |
| Ipswich light-house, 1849. | 42 41 06.81 | 210.1 | 70 46 07.32 | 166.6 |
| Ipswich Beacon, 1849. | 42 41 07.56 | 233.3 | 70 45 59.91 | 1363.9 |
| Ipswich, tall dark spire. | 42 40 53.18 | 1641.1 | 70 50 11.70 | 266.3 |
| Butler's Hill. | 42 39 29.50 | 910.3 | 70 40 18.33 | 417.5 |
| Burnham Brown, flag. | 42 39 32.00 | 987.4 | 70 49 25.88 | 589.5 |
| Burnham Essex, flag in tree. | 42 39 01.50 | 46.3 | 70 47 04.48 | 102.0 |
| Annisquam Harbor light-house (C. & G. S. & B.), 1834–49. | 42 39 43.02 | 1327.4 | 70 40 55.29 | 1258.1 |
| Annisquam, pole on rock. | 42 39 26.92 | 830.7 | 70 40 39.62 | 902.4 |
| Straitsmouth light-house, 1849. | 42 39 43.65 | 1346.8 | 70 35 22.52 | 512.9 |
| Straitsmouth light-house, 1851. | 42 39 44.37 | 1369.0 | 70 35 19.15 | 436.1 |
| Twopenny Loaf, flag. | 42 39 36.80 | 1135.5 | 70 43 08.84 | 201.3 |
| Rockport, red top church. | 42 39 28.80 | 888.7 | 70 37 09.70 | 220.9 |
| Dogtown, Methodist church. | 42 38 04.86 | 149.9 | 70 40 33.09 | 754.0 |
| Lufkin's Hill, flag. | 42 38 16.08 | 496.1 | 70 44 40.86 | 930.9 |
| Londoner Beacon, 1849. | 42 38 06.26 | 193.1 | 70 33 59.33 | 1351.7 |
| Essex powder-house. | 42 38 19.16 | 591.2 | 70 47 18.24 | 415.6 |
| Essex, red top church. | 42 37 59.96 | 1850.1 | 70 46 53.16 | 1211.2 |
| Beacon Hill 1. | 42 36 24.94 | 769.6 | 70 38 43.01 | 980.3 |
| Beacon Hill 2. | 42 36 11.74 | 362.2 | 70 38 38.64 | 880.9 |
| Beacon Hill, magnetic station, 1849. | 42 36 22.79 | 703.3 | 70 38 46.85 | 1067.9 |
| Thatcher's Island. | 42 38 10.94 | 337.5 | 70 34 46.28 | 1054.5 |
| Salvage. | 42 40 20.24 | 624.6 | 70 34 05.94 | 135.2 |

**VICINITY OF CAPE ANN—Continued.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 294 01 26 | 114 05 59 | Railcut | 10039.2 | 4.00170 |
| 336 55 35 | 156 56 51 | Thompson. | 6492.7 | 3.81243 |
| 344 38 59 | 164 39 17 | Choate | 2281.2 | 3.35816 |
| 78 01 26 | 258 00 27 | Tilton. | 2028.7 | 3.30721 |
| 340 01 03 | 160 02 32 | Thompson | 8721.2 | 3.94058 |
| 78 21 25 | 258 20 21 | Tilton. | 2198.5 | 3.34213 |
| 311 37 23 | 131 41 42 | Thompson | 11664.3 | 4.06686 |
| 6 31 01 | 186 30 35 | Brown's Hill. | 7686.5 | 3.88573 |
| 331 01 55 | 151 02 49 | Railcut | 3760.6 | 3.57526 |
| 42 54 41 | 222 52 18 | Thompson. | 7057.8 | 3.84867 |
| 225 21 25 | 45 22 40 | Tilton | 3564.6 | 3.55201 |
| 304 20 44 | 124 24 32 | Thompson. | 9294.8 | 3.96824 |
| 228 49 06 | 48 50 03 | Choate | 2532.0 | 3.40346 |
| 314 02 40 | 134 04 52 | Thompson. | 6193.3 | 3.79192 |
| 35 21 06 | 215 19 08 | Thompson | 6849.8 | 3.83568 |
| 103 25 49 | 283 21 19 | Tilton. | 9343.9 | 3.97053 |
| 324 18 14 | 144 19 23 | Railcut | 3953.0 | 3.59693 |
| 40 19 23 | 220 17 15 | Thompson. | 6676.4 | 3.82454 |
| 81 04 12 | 261 02 21 | Poole's Hill | 3764.1 | 3.57566 |
| 125 17 43 | 305 16 05 | Andrews' Point. | 4024.5 | 3.60471 |
| 80 55 13 | 260 53 20 | Poole's Hill | 3843.2 | 3.58469 |
| 124 25 05 | 304 23 25 | Andrews' Point. | 4074.6 | 3.61009 |
| 9 39 48 | 189 39 21 | Thompson | 5474.0 | 3.73830 |
| 99 29 15 | 279 27 32 | Choate. | 3508.5 | 3.54512 |
| 84 19 39 | 264 19 01 | Poole's Hill | 1283.3 | 3.10832 |
| 163 07 15 | 343 06 50 | Andrews' Point. | 2908.2 | 3.46362 |
| 287 26 43 | 107 27 47 | Railcut | 2261.6 | 3.35442 |
| 187 19 55 | 7 20 05 | Butler's Hill. | 2633.5 | 3.42054 |
| 337 55 11 | 157 55 46 | Thompson | 3135.2 | 3.49626 |
| 71 41 23 | 251 37 13 | Brown's Hill. | 8861.9 | 3.94752 |
| 83 59 02 | 263 55 39 | Railcut | 6852.4 | 3.83584 |
| 113 20 43 | 293 17 56 | Poole's Hill. | 6113.3 | 3.78628 |
| 175 33 02 | 355 32 51 | Tilton | 4766.3 | 3.67818 |
| 216 44 04 | 36 45 10 | Choate. | 3710.2 | 3.56940 |
| 252 53 13 | 72 57 40 | Butler's Hill | 9408.9 | 3.97354 |
| 299 51 08 | 119 53 13 | Thompson. | 4835.3 | 3.68442 |
| 171 42 10 | 351 42 00 | Railcut | 2430.3 | 3.38566 |
| 94 19 15 | 274 15 48 | Thompson. | 6997.9 | 3.84497 |
| 170 54 12 | 350 53 59 | Railcut | 2847.7 | 3.45449 |
| 97 31 25 | 277 27 55 | Thompson. | 7138.9 | 3.85363 |
| 232 48 30 | 52 48 33 | Beacon Hill 1 | 109.81 | 2.04064 |
| 81 26 49 | 261 23 58 | Railcut | 5809.3 | 3.76412 |
| 55 14 21 | 235 11 44 | Beacon Hill 2. | 6447.7 | 3.80940 |
| 12 58 08 | 192 57 41 | Thatcher's Island | 4093.8 | 3.61213 |
| 72 35 49 | 252 33 06 | Poole's Hill. | 5724.3 | 3.75772 |

**VICINITY OF CAPE ANN—Continued.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Cape Ann north light-house (C. & G. S. & B.), 1834–'49. | 42 38 21.29 | 657.1 | 70 34 31.03 | 707.0 |
| Cape Ann north light-house, 1878. | 42 38 21.25 | 655.8 | 70 34 31.05 | 707.4 |
| Cape Ann south light-house (C. & G. S. & B.), 1834–'49. | 42 38 12.82 | 395.5 | 70 34 31.68 | 721.8 |
| Cape Ann south light-house, 1878. | 42 38 12.82 | 395.5 | 70 34 31.78 | 724.1 |
| Milk Island, flag. | 42 37 41.64 | 1284.8 | 70 35 31.80 | 724.6 |
| Salt Island, flag. | 42 37 11.38 | 351.1 | 70 37 26.60 | 606.3 |
| Gloucester, east church. | 42 37 00.46 | 14.2 | 70 39 25.66 | 584.9 |
| Gloucester, Universalist church. | 42 36 47.66 | 1470.6 | 70 40 00.14 | 3.2 |
| Woodward's Hill, flag. | 42 36 59.74 | 1843.2 | 70 42 05.96 | 135.8 |
| Clark's mountain, flag in tree. | 42 36 59.50 | 1836.0 | 70 43 41.16 | 938.0 |
| Ten Pound Island light-house, 1849. | 42 36 06.66 | 205.5 | 70 39 57.58 | 1312.6 |
| Eastern Point light-house (C. & G. S. & B.), 1834–'49. | 42 34 49.14 | 1516.2 | 70 39 53.90 | 1229.1 |

**VICINITY OF SALEM.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| Brown's Hill. | 42 36 45.688 | 1409.7 | 70 50 49.984 | 1139.3 |
| Coddon (C. & G. S. & B.). | 42 30 59.166 | 1825.7 | 70 51 17.520 | 399.9 |
| Bolles. | 42 35 05.95 | 183.6 | 70 47 35.44 | 808.3 |
| Folly Hill. | 42 33 59.12 | 1824.3 | 70 54 48.20 | 1099.3 |
| Beverly Rocks. | 42 33 58.78 | 1813.8 | 70 50 14.98 | 341.7 |
| Beverly, powder-house. | 42 33 12.60 | 388.7 | 70 52 33.13 | 755.9 |
| Beverly, tall spire with turrets. | 42 32 51.06 | 1575.6 | 70 52 43.52 | 993.8 |
| Beverly Point, flag in tree. | 42 32 59.04 | 1821.8 | 70 54 15.46 | 352.7 |
| Baker's Island light-house (C. & G. S. & B.) 1834–'77. | 42 32 11.53 | 355.8 | 70 47 11.22 | 256.1 |
| Kettle Island. | 42 34 01.26 | 38.9 | 70 43 22.00 | 501.8 |
| Fort Lee. | 42 31 54.71 | 1688.2 | 70 52 28.94 | 660.4 |

## VICINITY OF CAPE ANN—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 79 00 49 | 258 57 48 | Railcut | 6206.4 | 3.79284 |
| 111 49 03 | 291 46 38 | Poole's Hill. | 5268.1 | 3.72165 |
| 58 00 48 | 237 57 57 | Beacon Hill 1 | 6771.3 | 3.83067 |
| 111 50 05 | 291 47 40 | Poole's Hill. | 5268.4 | 3.72168 |
| 81 22 42 | 261 19 41 | Railcut | 6147.2 | 3.78868 |
| 114 28 16 | 294 25 51 | Poole's Hill. | 5357.3 | 3.72895 |
| 59 50 47 | 239 47 57 | Beacon Hill 1 | 6622.8 | 3.82104 |
| 114 29 05 | 294 26 40 | Poole's Hill. | 5355.6 | 3.72881 |
| 90 28 57 | 270 26 37 | Railcut | 4707.5 | 3.67279 |
| 56 56 22 | 236 54 15 | Beacon Hill 2. | 5082.3 | 3.70606 |
| 114 54 59 | 294 53 57 | Railcut | 2306.4 | 3.36294 |
| 41 44 50 | 221 44 01 | Beacon Hill 2. | 2466.5 | 3.39208 |
| 84 35 10 | 264 32 12 | Thompson | 6033.0 | 3.78053 |
| 205 23 24 | 25 23 42 | Railcut. | 1448.8 | 3.16102 |
| 175 15 22 | 355 15 10 | Butler's Hill | 5011.4 | 3.69996 |
| 219 32 31 | 39 33 13 | Railcut. | 2209.6 | 3.34432 |
| 207 56 25 | 27 57 38 | Butler's Hill | 5231.4 | 3.71862 |
| 252 41 17 | 72 43 24 | Railcut. | 4476.5 | 3.65094 |
| 143 37 28 | 323 34 50 | Tilton | 8956.9 | 3.95216 |
| 258 14 39 | 78 17 50 | Railcut. | 6581.3 | 3.81831 |
| 204 25 45 | 24 26 25 | Railcut | 3260.8 | 3.51332 |
| 265 00 51 | 85 01 44 | Beacon Hill 2. | 1806.3 | 3.25678 |
| 228 21 47 | 48 25 15 | Thatcher's Island | 9377.6 | 3.97209 |
| 193 16 31 | 13 17 09 | Railcut. | 5507.9 | 3.74099 |

## VICINITY OF SALEM.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| 98 31 09.8 | 278 20 36.7 | Holt | 21536.5 | 4.333174 |
| 38 28 34.0 | 218 23 46.9 | Orne. | 15576.8 | 4.192479 |
| 123 52 53.2 | 303 42 39.3 | Holt | 24899.7 | 4.396194 |
| 223 59 47.4 | 44 04 50.7 | Thompson. | 14712.3 | 4.167681 |
| 124 46 28 | 304 44 16 | Brown | 5398.5 | 3.73227 |
| 240 07 13 | 60 09 46 | Thompson. | 5948.3 | 3.77439 |
| 319 05 35 | 139 07 57 | Coddon | 7344.5 | 3.86596 |
| 31 03 47 | 211 01 41 | Orne. | 8241.8 | 3.91602 |
| 14 26 43 | 194 26 01 | Coddon | 5723.0 | 3.75762 |
| 56 07 28 | 236 02 18 | Orne. | 12635.7 | 4.10160 |
| 337 14 56 | 157 15 47 | Coddon | 4464.3 | 3.64975 |
| 52 32 04 | 232 28 26 | Orne. | 9242.8 | 3.96580 |
| 330 22 30 | 150 23 28 | Coddon | 3971.5 | 3.59895 |
| 55 04 17 | 235 00 47 | Orne. | 8659.1 | 3.93748 |
| 312 18 45 | 132 20 45 | Coddon | 5493.0 | 3.73981 |
| 43 50 40 | 223 48 12 | Orne. | 7218.4 | 3.85844 |
| 68 21 47 | 248 19 01 | Coddon | 6048.7 | 3.78166 |
| 107 42 21 | 287 37 12 | Folly Hill. | 10941.6 | 4.03908 |
| 62 40 15 | 242 34 54 | Coddon | 12218.0 | 4.08700 |
| 57 06 08 | 237 03 33 | Baker's Island light-house. | 6230.9 | 3.79455 |
| *140 23 59 | 320 22 25 | Folly Hill | 4982.9 | 3.69748 |
| 66 35 04 | 246 31 24 | Orne. | 8099.2 | 3.90844 |

**VICINITY OF SALEM**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Legg's Hill. | 42 29 23.30 | 719.0 | 70 53 30.83 | 704.0 |
| Manchester church, dark spire. | 42 34 30.28 | 934.3 | 70 46 20.82 | 474.8 |
| Danvers Insane Asylum, tower | 42 34 51.74 | 1596.6 | 70 58 30.82 | 702.8 |
| Danvers Plain, tall spire. | 42 34 03.32 | 102.5 | 70 56 18.26 | 416.5 |
| Danvers, New Mills, tall spire. | 42 33 20.70 | 638.8 | 70 55 30.55 | 696.9 |
| South Danvers, tall spire. | 42 31 35.38 | 1091.7 | 70 55 40.55 | 925.5 |
| Dexter's Point. | 42 32 53.80 | 1660.1 | 70 50 44.26 | 1009.8 |
| Bowditch's Ledge Beacon. | 42 32 25.38 | 783.2 | 70 48 43.19 | 985.5 |
| Great Misery, flag. | 42 32 50.20 | 1549.0 | 70 47 49.23 | 1123.2 |
| Great Haste. | 42 32 05.29 | 163.3 | 70 50 32.51 | 741.9 |
| Little Haste Beacon. | 42 32 07.71 | 237.9 | 70 50 35.95 | 820.4 |
| Hardy's Rock Beacon. | 42 32 11.36 | 350.5 | 70 48 01.62 | 37.0 |
| Dodge's Hotel, cupola. | 42 32 02.86 | 88.2 | 70 53 49.30 | 1125.1 |
| Hospital Point light-house, 1877. | 42 32 47.60 | 1468.8 | 70 51 23.29 | 531.3 |
| Fort Pickering light-house, 1877. | 42 31 35.57 | 1097.6 | 70 52 01.07 | 24.4 |
| Great Aquavitae, stone beacon. | 42 31 34.58 | 1067.0 | 70 51 28.24 | 644.5 |
| Little Aquavitae, pole. | 42 31 34.78 | 1073.2 | 70 51 13.10 | 299.0 |
| Abbot's Rock, stone beacon. | 42 31 49.48 | 1526.8 | 70 51 46.34 | 1057.5 |
| North Gooseberry Island, flag. | 42 31 35.97 | 1109.9 | 70 47 39.19 | 894.4 |
| Eagle Island, flag. | 42 31 31.21 | 963.1 | 70 48 49.24 | 1123.8 |
| Coney Island, flag. | 42 31 42.89 | 1323.4 | 70 50 14.78 | 337.3 |
| Salem, south church, corner of Cambridge and Chestnut streets. | 42 31 12.02 | 370.9 | 70 53 59.36 | 1354.8 |
| Salem, Howard street church. | 42 31 28.12 | 867.7 | 70 53 34.04 | 776.9 |

**VICINITY OF SALEM**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 103 33 33 | 283 30 35 | Orne | 6191.7 | 3.79181 |
| 225 48 19 | 45 49 49 | Coddon. | 4244.2 | 3.62780 |
| 46 03 15 | 225 58 25 | Legg's Hill | 13638.6 | 4.13477 |
| 60 16 54 | 240 12 45 | Fort Lee. | 9673.6 | 3.98559 |
| 305 56 10 | 126 01 03 | Coddon | 12216.0 | 4.08693 |
| 354 32 21 | 174 32 46 | Orne. | 8724.9 | 3.94076 |
| 307 09 31 | 127 12 06 | Fort Lee | 6566.6 | 3.81734 |
| 273 36 19 | 93 37 20 | Folly Hill. | 2058.4 | 3.31352 |
| 307 04 40 | 127 07 31 | Coddon | 7239.9 | 3.85973 |
| 29 12 50 | 209 11 13 | Orne. | 6731.8 | 3.82813 |
| 195 04 03 | 15 04 38 | Folly Hill | 4593.0 | 3.66210 |
| 280 30 58 | 100 33 56 | Coddon. | 6106.9 | 3.78582 |
| 285 00 00 | 105 02 24 | Baker's Island light-house | 5033.3 | 3.70185 |
| 12 06 52 | 192 06 30 | Coddon. | 3617.2 | 3.55837 |
| 52 57 21 | 232 55 37 | Coddon | 4413.8 | 3.64482 |
| 79 36 48 | 259 34 15 | Fort Lee. | 5237.8 | 3.71915 |
| 54 14 29 | 234 12 08 | Coddon | 5858.8 | 3.76781 |
| 75 00 35 | 254 57 26 | Fort Lee. | 6608.8 | 3.82012 |
| 26 43 46 | 206 43 16 | Coddon | 2284.0 | 3.35869 |
| 83 00 24 | 262 59 05 | Fort Lee. | 2676.9 | 3.42764 |
| 24 10 03 | 204 09 35 | Coddon | 2318.0 | 3.36512 |
| 81 09 48 | 261 08 32 | Fort Lee. | 2609.8 | 3.41660 |
| 85 12 52 | 265 09 51 | Fort Lee | 6122.2 | 3.78691 |
| 109 45 35 | 289 41 00 | Folly Hill. | 9853.9 | 3.99361 |
| 159 28 06 | 339 27 26 | Folly Hill | 3830.5 | 3.58325 |
| 277 48 22 | 97 49 16 | Fort Lee. | 1851.0 | 3.26740 |
| 357 44 44 | 177 44 48 | Coddon | 3348.4 | 3.52484 |
| 61 30 05 | 241 25 41 | Orne. | 10162.5 | 4.00700 |
| 318 28 55 | 138 29 24 | Coddon | 1499.8 | 3.17603 |
| 26 40 14 | 206 39 13 | Legg's Hill. | 4566.6 | 3.65959 |
| 347 22 34 | 167 22 41 | Coddon | 1119.6 | 3.04907 |
| 114 08 54 | 294 08 13 | Fort Lee. | 1518.2 | 3.18134 |
| 5 14 47 | 185 14 44 | Coddon | 1103.4 | 3.04275 |
| 109 33 29 | 289 32 38 | Fort Lee. | 1836.8 | 3.26407 |
| 337 02 09 | 157 02 28 | Coddon | 1685.9 | 3.22683 |
| 27 53 02 | 207 51 51 | Legg's Hill. | 5102.3 | 3.70777 |
| 77 11 02 | 257 08 34 | Coddon | 5111.4 | 3.70854 |
| 141 07 20 | 321 05 35 | Beverly Rocks. | 5661.5 | 3.75293 |
| 73 43 39 | 253 41 59 | Coddon | 3526.1 | 3.54730 |
| 156 45 24 | 336 44 26 | Beverly Rocks. | 4955.9 | 3.69512 |
| 46 43 17 | 226 42 35 | Coddon | 1967.2 | 3.29384 |
| 96 48 27 | 276 46 56 | Fort Lee. | 3083.5 | 3.48904 |
| 276 06 36 | 96 08 25 | Coddon | 3715.5 | 3.57002 |
| 349 00 26 | 169 00 45 | Legg's Hill. | 3417.0 | 3.53365 |
| 160 02 50 | 340 02 00 | Folly Hill | 4957.0 | 3.69522 |
| 241 04 41 | 61 05 25 | Fort Lee. | 1697.1 | 3.22972 |

**VICINITY OF SALEM**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Derby's wharf light-house, 1877. | 42 30 59.91 | 1848.7 | 70 53 02.54 | 58.0 |
| Marblehead light-house, 1848–'77. | 42 30 19.76 | 609.7 | 70 50 03.02 | 68.9 |
| Marblehead, black top church. | 42 30 25.66 | 791.8 | 70 50 54.11 | 1235.3 |
| Marblehead Rock Beacon. | 42 30 11.95 | 367.7 | 70 49 34.48 | 787.2 |
| Marblehead Neck, flag. | 42 29 46.94 | 1448.7 | 70 50 29.04 | 663.1 |
| Cat Island flag-staff, 1848. | 42 30 43.52 | 1342.9 | 70 48 55.42 | 1265.1 |
| Cat Island, east rock. | 42 30 32.61 | 1006.2 | 70 48 45.00 | 1027.3 |
| Boulder west of Salem turnpike. | 42 30 21.92 | 676.4 | 70 56 07.38 | 168.5 |
| Ware's Hill, flag-staff, 1848. | 42 30 40.60 | 1252.7 | 70 54 32.79 | 748.5 |
| Halfway Rock Beacon. | 42 30 09.38 | 289.5 | 70 46 31.40 | 716.9 |
| Brookhouse's house. | 42 29 08.56 | 264.1 | 70 53 13.76 | 314.3 |
| Ocean House, cupola. | 42 28 53.73 | 1658.0 | 70 52 33.64 | 768.3 |
| Tinker's Island, pole on house. | 42 28 57.71 | 1780.8 | 70 50 07.28 | 166.3 |
| Church spire summer-house. | 42 28 55.14 | 1701.5 | 70 53 03.45 | 78.8 |
| Summer-house on high rock. | 42 28 05.06 | 156.2 | 70 56 48.86 | 1116.1 |

**BOSTON BAY.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| Nahant. | 42 25 04.764 | 147.0 | 70 54 18.232 | 416.8 |
| Dorchester Heights. | 42 20 03.428 | 105.8 | 71 02 35.910 | 822.1 |
| Deer Island. | 42 21 01.282 | 39.6 | 70 57 30.989 | 709.3 |
| Governor's Island. | 42 21 08.312 | 256.5 | 71 00 39.030 | 893.3 |
| Boston State House (C. & G. S. & B.). | 42 21 29.596 | 913.2 | 71 03 51.040 | 1168.1 |
| Long Island Head light-house, 1846–1860. | 42 19 48.132 | 1485.0 | 70 57 24.123 | 552.3 |
| Powderhorn 2. 1877. | 42 24 04.564 | 140.8 | 71 01 52.055 | 1190.5 |

**VICINITY OF SALEM**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 270 31 50 | 90 33 01 | Coddon | 2397.5 | 3.37976 |
| 12 13 36 | 192 13 17 | Legg's Hill. | 3049.7 | 3.48426 |
| 125 34 26 | 305 33 36 | Coddon | 2090.7 | 3.32030 |
| 228 39 22 | 48 41 18 | Baker's Island light-house. | 5222.3 | 3.71786 |
| 87 12 26 | 267 07 42 | Orne | 9608.6 | 3.98266 |
| 140 58 41 | 320 56 03 | Folly Hill. | 8480.5 | 3.92842 |
| 121 47 05 | 301 45 55 | Coddon | 2767.1 | 3.44203 |
| 134 25 24 | 314 21 52 | Folly Hill. | 10019.6 | 4.00085 |
| 94 05 21 | 274 00 20 | Orne | 10195.5 | 4.00841 |
| 153 35 42 | 333 35 09 | Coddon. | 2488.3 | 3.39590 |
| 98 29 02 | 278 27 26 | Coddon | 3279.9 | 3.51586 |
| 114 16 59 | 294 14 35 | Fort Lee. | 5345.4 | 3.72798 |
| 103 15 34 | 283 13 51 | Coddon | 3577.1 | 3.55354 |
| 162 07 16 | 342 06 15 | Beverly Rocks. | 6684.8 | 3.82509 |
| 260 07 08 | 80 10 24 | Coddon | 6716.5 | 3.82714 |
| 195 04 59 | 15 05 53 | Folly Hill. | 6941.3 | 3.84144 |
| 262 39 34 | 82 41 46 | Coddon | 4494.4 | 3.65267 |
| 329 19 10 | 149 19 52 | Legg's Hill. | 2773.3 | 3.44299 |
| 90 09 53 | 270 02 11 | Orne | 15595.5 | 4.19300 |
| 103 15 46 | 283 12 33 | Coddon. | 6710.1 | 3.82673 |
| 106 34 15 | 286 31 05 | Orne | 6686.4 | 3.82519 |
| 166 29 29 | 346 28 25 | Folly Hill. | 9220.8 | 3.96477 |
| 204 10 29 | 24 11 20 | Coddon | 4242.8 | 3.62765 |
| 107 53 47 | 287 50 10 | Orne. | 7697.3 | 3.88634 |
| 99 39 40 | 279 37 22 | Legg's Hill | 4715.3 | 3.67351 |
| 156 50 14 | 336 49 27 | Coddon. | 4076.5 | 3.61029 |
| 109 15 37 | 289 12 20 | Orne | 7038.2 | 3.84746 |
| 212 16 55 | 32 18 05 | Coddon. | 4527.5 | 3.65586 |
| 158 48 45 | 338 48 01 | Orne | 4143.7 | 3.61739 |
| 241 53 24 | 61 55 38 | Legg's Hill. | 5127.3 | 3.70989 |

**BOSTON BAY.**

| | | | | |
|---|---|---|---|---|
| 37 09 11.4 | 217 00 43.5 | Blue Hill | 28652.6 | 4.457164 |
| 83 37 52.4 | 263 23 44.7 | Prospect Waltham. | 28933.7 | 4.461404 |
| 23 28 40.0 | 203 25 47.3 | Blue Hill | 14781.5 | 4.169719 |
| 109 12 15.5 | 289 03 43.8 | Prospect Waltham. | 18394.8 | 4.264695 |
| 40 02 12.6 | 219 55 54.7 | Blue Hill | 20027.3 | 4.301623 |
| 99 59 07.6 | 279 47 10.3 | Prospect Waltham. | 24720.4 | 4.393056 |
| 162 57 02.7 | 342 56 13.5 | Powderhorn | 5692.4 | 3.755292 |
| 301 31 02.6 | 121 35 17.7 | Nantasket. | 10178.5 | 4.007682 |
| 209 37 54.4 | 29 39 14.6 | Powderhorn | 5505.9 | 3.740825 |
| 14 24 17.8 | 194 22 15.6 | Blue Hill. | 16744.1 | 4.223863 |
| 304 05 21.5 | 124 07 25.3 | Nantasket | 5086.7 | 3.706439 |
| 44 55 19.1 | 224 48 56.7 | Blue Hill. | 18467.4 | 4.266407 |
| 18 10 42.7 | 198 07 20.4 | Blue Hill | 22100.3 | 4.344397 |
| 85 40 59.6 | 265 31 58.0 | Prospect Waltham. | 18426.6 | 4.265445 |

**BOSTON BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Blind Asylum. | 42 20 07.037 | 217.1 | 71 02 32.861 | 752.3 |
| White's Hill. | 42 12 52.466 | 1618.8 | 70 58 39.300 | 901.4 |
| Great Quincy. | 42 16 29.026 | 895.6 | 70 57 06.869 | 157.4 |
| Scituate (C. & G. S. and B.). | 42 14 14.646 | 451.9 | 70 49 51.228 | 1174.6 |
| Hayden's Hotel. | 42 15 10.370 | 320.0 | 70 46 20.130 | 461.4 |
| Cat Hill. | 42 13 19.178 | 591.8 | 70 45 20.317 | 466.0 |
| Blue Hill (Borden). | 42 12 43.676 | 1347.5 | 71 06 52.709 | 1209.0 |
| Cambridge Observatory, west transit, astronomical azimuth station, 1867–1869. | 42 22 53.481 | 1650.3 | 71 07 44.478 | 1017.4 |
| Cambridge Observatory Meridian mark (east Transit or Meridian Circle), 1845–1847. | 42 25 47.43 | 1463.5 | 71 07 43.52 | 994.8 |
| Nahant (Borden). | 42 25 40.21 | 1240.7 | 70 55 16.96 | 387.6 |
| Castle Hill (Borden). | 42 29 19.54 | 602.9 | 71 02 42.12 | 961.8 |
| Ballard. | 42 27 17.56 | 541.9 | 70 59 32.57 | 744.3 |
| Waite 1. | 42 26 00.83 | 25.6 | 71 03 57.96. | 1324.8 |
| Waite 2. | 42 26 20.43 | 630.6 | 71 01 13.14 | 300.3 |
| Little Nahant. | 42 26 13.27 | 409.6 | 70 55 52.09 | 1190.5 |
| Egg Rock light-house, 1877. | 42 26 00.76 | 23.4 | 70 53 54.02 | 1234.7 |
| Dread Ledge Beacon. | 42 27 23.19 | 715.6 | 70 53 43.54 | 994.8 |
| Swampscott church. | 42 28 06.14 | 189.4 | 70 54 58.40 | 1334.0 |
| Grover's Cliff. | 42 23 22.79 | 703.4 | 70 58 08.65 | 197.9 |
| Lynn, east church, green tower. | 42 28 07.12 | 219.7 | 70 56 16.41 | 374.9 |
| Lynn, west church, turret. | 42 27 45.71 | 1410.4 | 70 57 37.00 | 845.3 |
| Lynn, high rock, pole near swing. | 42 28 04.96 | 153.0 | 70 56 52.10 | 1190.2 |
| Egg Rock. | 42 26 00.40 | 12.3 | 70 53 53.34 | 1219.2 |

**BOSTON BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 108 48 23.3 | 288 39 49.5 | Prospect Waltham | 18424.5 | 4.265397 |
| 187 15 23.6 | 7 15 51.1 | Powderhorn 2. | 7388.2 | 3.868539 |
| 88 42 52.3 | 268 37 20.8 | Blue Hill | 11319.1 | 4.053812 |
| 210 44 56.2 | 30 47 50.4 | Nantasket. | 11607.3 | 4.064731 |
| 229 13 32.3 | 49 15 24.4 | Nantasket | 5040.9 | 3.702512 |
| 17 36 16.5 | 197 35 14.4 | White's Hill. | 7009.9 | 3.845710 |
| 140 22 23.2 | 320 19 22.3 | Nantasket | 9659.7 | 3.984962 |
| 78 13 24.3 | 258 07 29.4 | White's Hill. | 12372.9 | 4.092473 |
| 70 27 43.3 | 250 25 21.4 | Scituate | 5136.0 | 3.710626 |
| 117 40 36.5 | 297 25 13.5 | Nantasket. | 12397.8 | 4.093344 |
| 105 25 39.1 | 285 22 37.0 | Scituate | 6443.9 | 3.809150 |
| 158 12 59.8 | 338 12 19.6 | Hayden's Hotel. | 3694.7 | 3.567583 |
| 116 03 16.0 | 295 32 02.3 | Wachusett | 70702.2 | 4.849433 |
| 180 45 45.0 | 0 46 03.8 | Holt. | 47656.1 | 4.678118 |
| 268 47.9 | 88 47.9 | Cambridge Observatory (Dome) | 13.571 | 1.13262 |
| 291 29 34 | 111 33 31 | Powderhorn | 8639.7 | 3.93650 |
| 2 31 33 | 182 31 20 | Corey. | 9699.3 | 3.98674 |
| 340 32 58 | 160 36 37 | Scituate | 22428.5 | 4.350801 |
| 33 41 13 | 213 33 25 | Blue Hill (Borden). | 28773.5 | 4.458992 |
| 327 38 34 | 147 47 13 | Scituate | 33026.5 | 4.518862 |
| 10 35 48 | 190 32 59 | Blue Hill (Borden). | 31257.7 | 4.494971 |
| 299 39 55 | 119 43 27 | Nahant | 8270.8 | 3.91755 |
| 28 11 17 | 208 09 43 | Powderhorn. | 6751.0 | 3.82937 |
| 321 12 13 | 141 13 38 | Powderhorn | 4597.3 | 3.66250 |
| 358 54 57 | 178 55 02 | Boston State House. | 8370.3 | 3.92274 |
| 283 47 28 | 103 52 08 | Nahant | 9767.9 | 3.98980 |
| 11 59 02 | 191 58 36 | Powderhorn. | 4281.9 | 3.63164 |
| 314 34 00 | 134 35 03 | Nahant | 3012.0 | 3.47886 |
| 64 17 28 | 244 13 25 | Powderhorn. | 9135.7 | 3.96074 |
| 144 30 58 | 324 28 16 | Orne | 9457.4 | 3.97577 |
| 201 12 11 | 21 13 57 | Coddon. | 9877.3 | 3.99464 |
| 10 31 16 | 190 30 53 | Nahant | 4344.1 | 3.63790 |
| 88 47 00 | 268 43 04 | Ballard. | 7977.2 | 3.90185 |
| 19 24 43 | 199 24 07 | Little Nahant | 3691.9 | 3.56725 |
| 76 34 05 | 256 31 00 | Ballard. | 6440.8 | 3.80894 |
| 348 50 00 | 168 50 25 | Deer Island | 4450.5 | 3.64841 |
| 104 13 09 | 284 10 39 | Powderhorn. | 5269.6 | 3.72178 |
| 16 18 44 | 196 17 28 | Grover's Cliff | 9140.5 | 3.96097 |
| 71 10 38 | 251 08 26 | Ballard. | 4735.4 | 3.67536 |
| 5 05 56 | 185 05 35 | Grover's Cliff | 8144.8 | 3.91088 |
| 71 47 35 | 251 46 17 | Ballard. | 2780.0 | 3.44405 |
| 11 22 15 | 191 21 23 | Grover's Cliff | 8880.6 | 3.94844 |
| 68 16 00 | 248 14 12 | Ballard. | 3947.2 | 3.59629 |
| 18 20 18 | 198 20 01 | Nahant | 1808.7 | 3.25737 |
| 98 20 14 | 278 18 54 | Little Nahant. | 2743.1 | 3.43824 |

**BOSTON BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Crusoe House, flagstaff. | 42 26 10.65 | 328.6 | 70 58 07.58 | 173.3 |
| South Boston Point. | 42 20 13.02 | 401.7 | 71 01 33.45 | 765.8 |
| Castle Island. | 42 20 19.26 | 594.5 | 71 00 45.65 | 1045.0 |
| Nahant 2. 1860. | 42 25 04.80 | 148.1 | 70 54 18.33 | 419.1 |
| Winthrop Head. | 42 22 04.07 | 125.6 | 70 58 06.04 | 138.2 |
| Winthrop Head 2. 1877. | 42 22 04.36 | 134.5 | 70 58 08.25 | 188.8 |
| Tuft's College. | 42 24 26.84 | 828.2 | 71 07 13.85 | 316.7 |
| Ten Hill Farm, flag. | 42 23 50.88 | 1569.8 | 71 05 15.26 | 349.0 |
| Ten Hill Farm 2. 1860. | 42 23 50.48 | 1557.6 | 71 05 15.44 | 353.1 |
| Governor's Island 2. 1860. | 42 21 09.10 | 280.8 | 71 00 42.86 | 980.9 |
| Governor's Island 3. 1877. | 42 21 08.84 | 272.8 | 71 00 41.12 | 941.1 |
| East Boston. | 42 22 53.13 | 1639.9 | 71 02 11.74 | 268.5 |
| East Boston Point, flag. | 42 21 58.24 | 1796.9 | 71 01 44.75 | 1023.9 |
| East Boston Iron Works, chimney. | 42 22 55.76 | 1720.4 | 71 01 48.44 | 1108.1 |
| East Boston Reservoir. | 42 22 52.76 | 1627.9 | 71 02 09.84 | 225.1 |
| East Boston Reservoir 2. 1877. | 42 22 52.56 | 1621.8 | 71 02 09.91 | 226.7 |
| East Boston Elevator. | 42 21 47.59 | 1468.4 | 71 02 15.51 | 354.9 |
| East Boston Dry Dock, post. | 42 21 44.76 | 1381.1 | 71 01 54.81 | 1254.2 |
| East Boston ship-yard, east wharf post. | 42 21 50.12 | 1546.5 | 71 01 41.59 | 951.7 |
| East Boston, brick church, dark spire. | 42 22 26.77 | 826.0 | 71 02 21.89 | 500.8 |
| East Boston, granite church, dark spire. | 42 22 16.06 | 495.5 | 71 02 28.44 | 650.7 |
| Long wharf. | 42 21 37.65 | 1162.0 | 71 02 53.75 | 1229.7 |
| Long wharf 2, post. 1860. | 42 21 36.45 | 1124.7 | 71 02 53.54 | 1225.2 |

**BOSTON BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 0 16 06 | 180 16 05 | Grover's Cliff | 5179.3 | 3.71427 |
| 52 52 37 | 232 50 06 | Powderhorn. | 6437.1 | 3.80869 |
| 126 53 40 | 306 52 07 | Boston State House | 3937.1 | 3.59518 |
| 176 36 10 | 356 35 58 | Powderhorn. | 7160.8 | 3.85496 |
| 117 06 13 | 297 04 08 | Boston State House | 4766.1 | 3.67816 |
| 167 41 31 | 347 40 46 | Powderhorn. | 7119.0 | 3.85242 |
| 0 11 37 | 180 11 36 | Nantasket | 12623.2 | 4.10117 |
| 79 54 21 | 259 49 16 | Powderhorn. | 10538.5 | 4.02278 |
| 125 46 32 | 305 44 00 | Powderhorn | 6369.4 | 3.80410 |
| 223 01 26 | 43 03 59 | Nahant 2. | 7630.4 | 3.88255 |
| 59 09 16 | 239 06 18 | Blind Asylum | 7055.7 | 3.84854 |
| 125 56 30 | 305 53 59 | Powderhorn 2. | 6322.1 | 3.80086 |
| 275 16 38 | 95 20 15 | Powderhorn | 7391.8 | 3.86875 |
| 319 40 15 | 139 42 32 | Boston State House. | 7171.8 | 3.85563 |
| 264 44 49 | 84 47 06 | Powderhorn | 4667.9 | 3.66912 |
| 336 08 53 | 156 09 50 | Boston State House. | 4766.2 | 3.67817 |
| 336 02 33 | 156 03 30 | Boston State House | 4756.6 | 3.67730 |
| 112 30 50 | 192 29 30 | Tuft's College. | 2931.3 | 3.46706 |
| 52 45 12 | 232 43 58 | Blind Asylum | 3163.3 | 3.50014 |
| 163 43 45 | 343 42 58 | Powderhorn. | 5643.8 | 3.75157 |
| 53 18 13 | 233 16 58 | Blind Asylum | 3190.4 | 3.50384 |
| 163 20 40 | 343 19 52 | Powderhorn 2. | 5659.9 | 3.75281 |
| 298 13 01 | 118 16 10 | Deer Island | 7292.4 | 3.86287 |
| 6 02 02 | 186 01 46 | Dorchester Heights. | 5265.0 | 3.72140 |
| 315 40 50 | 135 41 34 | Governor's Island | 2153.1 | 3.33307 |
| 336 06 12 | 156 06 52 | Castle Island. | 3340.2 | 3.52377 |
| 177 48 15 | 357 48 13 | Powderhorn | 2128.2 | 3.32801 |
| 260 33 37 | 80 36 05 | Grover's Cliff. | 5096.6 | 3.70728 |
| 112 46 26 | 292 44 21 | Ten Hill Farm 2 | 4603.4 | 3.66308 |
| 190 24 22 | 10 24 34 | Powderhorn. | 2256.5 | 3.35344 |
| 327 35 18 | 147 36 18 | Governor's Island 3 | 3790.7 | 3.57872 |
| 5 52 42 | 185 52 27 | Blind Asylum. | 5134.0 | 3.71046 |
| 264 44 59 | 84 47 46 | Winthrop Head 2 | 5681.5 | 3.75446 |
| 7 17 54 | 187 17 42 | Blind Asylum. | 3128.1 | 3.49528 |
| 350 11 57 | 170 12 11 | South Boston Point | 2872.6 | 3.45828 |
| 16 06 58 | 196 06 32 | Blind Asylum. | 3138.7 | 3.49675 |
| 356 26 17 | 176 26 22 | South Boston Point | 3001.9 | 3.47739 |
| 20 15 25 | 200 14 50 | Blind Asylum. | 3390.3 | 3.53024 |
| 192 44 50 | 12 45 10 | Powderhorn | 3097.6 | 3.49103 |
| 198 58 51 | 18 58 59 | East Boston Reservoir. | 847.7 | 2.92826 |
| 193 57 33 | 13 57 58 | Powderhorn | 3453.6 | 3.53827 |
| 200 35 15 | 20 35 28 | East Boston Reservoir. | 1209.3 | 3.08255 |
| 197 17 16 | 17 17 58 | Powderhorn | 4751.5 | 3.67683 |
| 286 21 06 | 106 22 37 | Governor's Island. | 3213.4 | 3.50697 |
| 197 06 04 | 17 06 45 | Powderhorn | 4785.5 | 3.67993 |
| 350 15 36 | 170 15 50 | Blind Asylum. | 2799.1 | 3.44702 |

**BOSTON BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Neptune House, flagstaff. | 42 25 43.48 | 1341.5 | 70 58 46.76 | 1068.9 |
| Naval Hospital. | 42 23 22.58 | 696.7 | 71 02 55.94 | 1279.6 |
| Cushman's house, cupola. | 42 24 59.35 | 1831.2 | 71 00 44.60 | 1019.7 |
| Nahant Hotel, cupola. | 42 25 09.20 | 283.9 | 70 54 19.84 | 453.6 |
| Stone powder-house. | 42 24 00.40 | 12.3 | 71 07 00.17 | 3.9 |
| Grain mill, near turnpike, west chimney. | 42 24 05.18 | 159.8 | 71 05 51.68 | 1181.8 |
| Brick factory, near Mystic River, cupola. | 42 24 32.76 | 1010.8 | 71 05 27.07 | 619.0 |
| Tall chimney, north side of Mystic River. | 42 24 36.17 | 1116.1 | 71 05 21.94 | 501.7 |
| Chelsea church. | 42 24 32.98 | 1017.5 | 71 00 26.28 | 600.8 |
| Chelsea bridge. | 42 22 56.55 | 1744.8 | 71 02 55.67 | 1273.5 |
| Chelsea, dark spire, cross. | 42 23 40.47 | 1248.7 | 71 01 54.68 | 1250.6 |
| Chelsea, white spire, martin-hole windows. | 42 23 24.55 | 757.5 | 71 02 19.91 | 455.6 |
| Chelsea, white spire, with clock. | 42 23 27.33 | 843.3 | 71 02 18.18 | 415.8 |
| Chelsea, white spire, three tiers of windows. | 42 23 36.20 | 1117.0 | 71 02 16.13 | 368.9 |
| Chelsea, tall dark spire. | 42 23 30.56 | 942.9 | 71 02 16.90 | 386.6 |
| Chelsea, brown tower. | 42 23 28.98 | 894.2 | 71 01 46.40 | 1061.3 |
| Edgeworth Mills, round chimney. | 42 25 01.38 | 42.6 | 71 04 30.87 | 705.8 |
| Malden church, tall spire. | 42 25 38.84 | 1198.3 | 71 04 01.56 | 35.6 |
| Malden, yellow spire. | 42 25 38.75 | 1195.6 | 71 04 01.44 | 32.9 |
| Malden Bridge, yellow house chimney, at toll-gate. | 42 23 34.58 | 1066.9 | 71 04 09.58 | 219.1 |
| Malden Bridge. | 42 23 11.41 | 352.1 | 71 04 13.50 | 308.8 |
| Medford, Unitarian church. | 42 25 13.97 | 431.0 | 71 06 56.23 | 1285.5 |
| Medford, tall square chimney, near bridge. | 42 24 52.20 | 1610.6 | 71 06 31.54 | 721.1 |

**BOSTON BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 348 38 43 | 168 39 09 | Grover's Cliff | 4427.5 | 3.64616 |
| 54 16 33 | 234 14 28 | Powderhorn. | 5218.6 | 3.71755 |
| 323 12 37 | 143 14 08 | Governor's Island 3 | 5152.3 | 3.71200 |
| 354 59 41 | 174 59 57 | Blind Asylum. | 6056.8 | 3.78224 |
| 201 05 59 | 21 06 48 | Ballard | 4571.0 | 3.66001 |
| 309 51 38 | 129 53 23 | Grover's Cliff. | 4646.8 | 3.66715 |
| 50 18 35 | 230 13 00 | Dorchester Heights | 14758.4 | 4.16904 |
| 79 08 42 | 259 03 37 | Powderhorn. | 10529.1 | 4.02239 |
| 268 53 55 | 88 57 23 | Powderhorn | 7048.7 | 3.84811 |
| 12 31 59 | 192 31 17 | Corey. | 6543.6 | 3.81582 |
| 270 08 13 | 90 10 55 | Powderhorn | 5481.1 | 3.73887 |
| 298 40 39 | 118 41 03 | Ten Hill Farm 2. | 944.8 | 2.97534 |
| 279 58 15 | 100 00 40 | Powderhorn | 4993.8 | 3.69843 |
| 85 43 56 | 265 42 44 | Tuft's College. | 2448.7 | 3.38894 |
| 281 25 17 | 101 27 39 | Powderhorn | 4898.0 | 3.69002 |
| 83 35 40 | 263 34 24 | Tuft's College. | 2575.0 | 3.41080 |
| 66 00 00 | 245 59 02 | Powderhorn | 2146.1 | 3.33165 |
| 19 38 22 | 199 36 55 | Dorchester Heights. | 8830.2 | 3.94597 |
| 179 32 09 | 359 32 09 | Naval Hospital | 803.4 | 2.90492 |
| 276 42 49 | 96 43 20 | East Boston Reservoir 2. | 1054.2 | 3.02293 |
| 93 52 08 | 273 49 52 | Ten Hill Farm 2 | 4601.7 | 3.66292 |
| 101 07 14 | 281 03 39 | Tuft's College. | 7438.4 | 3.87148 |
| 101 17 10 | 281 15 12 | Ten Hill Farm 2 | 4093.8 | 3.61213 |
| 105 59 02 | 281 55 44 | Tuft's College. | 6991.7 | 3.84458 |
| 100 00 36 | 279 58 36 | Ten Hill Farm 2 | 4116.9 | 3.61457 |
| 349 50 57 | 169 51 03 | East Boston Reservoir. | 1083.6 | 3.03488 |
| 96 09 07 | 276 07 06 | Ten Hill Farm 2 | 4124.9 | 3.61541 |
| 353 52 27 | 173 52 31 | East Boston Reservoir. | 1348.2 | 3.12974 |
| 352 07 33 | 172 07 38 | East Boston Reservoir | 1177.7 | 3.07105 |
| 104 22 14 | 284 18 54 | Tuft's College. | 7009.9 | 3.84571 |
| 25 36 51 | 205 36 41 | East Boston Reservoir | 1239.8 | 3.09334 |
| 173 21 32 | 353 21 28 | Powderhorn. | 1109.1 | 3.04497 |
| 295 41 53 | 115 43 40 | Powderhorn | 4031.9 | 3.60551 |
| 74 03 28 | 254 01 38 | Tuft's College. | 3876.1 | 3.58839 |
| 314 25 49 | 134 27 16 | Powderhorn | 4149.0 | 3.61794 |
| 30 18 36 | 210 15 54 | Corey. | 10914.7 | 4.03801 |
| 26 51 52 | 206 51 02 | Ten Hill Farm 2 | 3744.7 | 3.57342 |
| 63 15 04 | 243 12 54 | Tuft's College. | 4927.0 | 3.69258 |
| 183 22 12 | 3 22 20 | Waite 1 | 4520.5 | 3.65519 |
| 253 32 07 | 73 33 40 | Powderhorn. | 3280.9 | 3.51599 |
| 243 06 02 | 63 07 38 | Powderhorn 2 | 3627.1 | 3.55956 |
| 281 36 35 | 101 37 58 | East Boston Reservoir 2. | 2886.6 | 3.46038 |
| 287 03 16 | 107 06 41 | Powderhorn | 7277.3 | 3.86197 |
| 9 53 45 | 189 53 01 | Corey. | 8788.2 | 3.94390 |
| 282 53 30 | 102 56 38 | Powderhorn | 6558.1 | 3.81678 |
| 51 02 48 | 231 02 19 | Tuft's College. | 1244.3 | 3.09492 |

**BOSTON BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Winnisimett, church with clock. | 42 23 27.35 | 843.9 | 71 02 18.18 | 415.8 |
| Somerville, church on hill. | 42 23 12.18 | 375.8 | 71 05 52.37 | 1197.8 |
| Somerville, red church, 1860. | 42 23 11.98 | 369.6 | 71 05 52.46 | 1200.0 |
| Somerville church, near Malden Bridge. | 42 23 07.43 | 229.3 | 71 04 36.63 | 837.9 |
| Mount Auburn. | 42 22 10.94 | 337.6 | 71 08 40.37 | 923.7 |
| Cambridge, Baptist church. | 42 22 34.42 | 1061.9 | 71 07 07.71 | 176.4 |
| Cambridge, Unitarian church. | 42 22 28.70 | 885.5 | 71 07 10.78 | 246.6 |
| Cambridge, gas works chimney. | 42 22 24.35 | 751.3 | 71 07 36.78 | 841.5 |
| Cambridgeport, Universalist church. | 42 21 47.52 | 1466.2 | 71 06 00.88 | 20.1 |
| Cambridgeport, observatory dome. | 42 21 19.06 | 588.1 | 71 06 35.85 | 820.5 |
| Cambridgeport, redoubt, flagstaff. | 42 21 23.89 | 737.1 | 71 06 17.21 | 393.9 |
| Cambridgeport, flagstaff near engine-house. | 42 21 45.58 | 1406.4 | 71 05 15.64 | 357.9 |
| East Cambridge court-house, cupola. | 42 22 11.95 | 368.7 | 71 04 48.56 | 1111.1 |
| East Cambridge, church near court-house. | 42 22 11.46 | 353.5 | 71 04 50.78 | 1161.9 |
| West Cambridge, tall spire with clock. | 42 24 55.63 | 1716.6 | 71 09 15.82 | 361.8 |
| Graves. | 42 21 53.66 | 1655.7 | 70 52 12.61 | 288.5 |
| Great Brewster. | 42 20 01.96 | 60.5 | 70 53 45.18 | 1034.3 |
| Great Brewster 2. 1860. | 42 20 01.68 | 51.8 | 70 53 45.22 | 1035.3 |
| Point Shirley foundry chimney. | 42 21 31.80 | 981.2 | 70 58 20.22 | 462.7 |
| Battery wharf. | 42 22 01.32 | 40.8 | 71 02 59.22 | 1355.0 |
| Guide Post, west end of mill-dam. | 42 20 55.63 | 1716.4 | 71 05 51.00 | 1167.2 |
| Belle Isle. | 42 22 57.30 | 1767.9 | 70 59 56.35 | 1289.0 |
| Navy-yard, battery near flagstaff. | 42 22 23.97 | 739.6 | 71 03 06.32 | 144.6 |

**BOSTON BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 154 17 08 | 334 16 01 | Waite 1 | 5256.8 | 3.72072 |
| 207 26 36 | 27 26 54 | Powderhorn. | 1298.4 | 3.11341 |
| 322 18 52 | 142 21 04 | Dorchester Heights | 7357.3 | 3.86672 |
| 31 14 29 | 211 13 02 | Corey. | 5730.1 | 3.75816 |
| 215 28 48 | 35 29 13 | Ten Hill Farm 2 | 1458.8 | 3.16400 |
| 253 30 26 | 73 33 08 | Powderhorn. | 5735.0 | 3.75853 |
| 334 02 24 | 154 03 45 | Dorchester Heights | 6313.8 | 3.80029 |
| 44 43 16 | 224 40 57 | Corey. | 6687.3 | 3.82525 |
| 249 22 13 | 69 26 48 | Powderhorn | 9978.8 | 3.99908 |
| 280 52 45 | 100 56 00 | Boston State House. | 6742.5 | 3.82882 |
| 248 52 47 | 68 56 20 | Powderhorn | 7739.8 | 3.88873 |
| 306 48 18 | 126 51 21 | Dorchester Heights. | 7771.6 | 3.89051 |
| 247 51 56 | 67 55 31 | Powderhorn | 7870.3 | 3.89599 |
| 305 26 41 | 125 29 46 | Dorchester Heights. | 7706.5 | 3.88786 |
| 9 38 39 | 189 38 22 | Corey | 3473.2 | 3.54073 |
| 187 53 52 | 7 54 07 | Tuft's College. | 3815.8 | 3.58158 |
| 101 12 49 | 281 11 02 | Mount Auburn | 3720.1 | 3.57056 |
| 233 21 10 | 53 23 58 | Powderhorn. | 7094.1 | 3.85090 |
| 54 30 43 | 234 29 45 | Corey | 2427.6 | 3.38517 |
| 171 28 10 | 351 27 44 | Tuft's College. | 5859.1 | 3.76783 |
| 57 02 27 | 237 01 16 | Corey | 2864.3 | 3.45702 |
| 113 54 54 | 293 53 18 | Mount Auburn. | 3583.5 | 3.55431 |
| 59 42 43 | 239 40 51 | Corey | 4415.4 | 3.64497 |
| 151 29 10 | 331 27 50 | Tuft's College. | 5663.2 | 3.75306 |
| 55 33 41 | 235 31 31 | Corey | 5374.8 | 3.73036 |
| 89 40 36 | 269 38 00 | Mount Auburn. | 5304.2 | 3.72462 |
| 189 40 48 | 9 41 29 | Waite 1 | 7179.6 | 3.85610 |
| 229 28 28 | 49 30 29 | Powderhorn. | 5378.5 | 3.73066 |
| 278 45 50 | 98 50 49 | Powderhorn | 10269.7 | 4.01156 |
| 348 14 01 | 168 14 51 | Corey. | 8265.5 | 3.91727 |
| 77 31 26 | 257 27 51 | Deer Island | 7463.5 | 3.87294 |
| 154 01 54 | 334 00 29 | Nahant. | 6559.5 | 3.81687 |
| 13 45 10 | 193 44 46 | Nantasket | 3375.5 | 3.52834 |
| 109 31 15 | 289 28 43 | Deer Island. | 5483.8 | 3.73908 |
| 123 59 32 | 303 54 05 | Powderhorn | 13427.0 | 4.12798 |
| 175 22 23 | 355 22 01 | Nahant 2. | 9383.4 | 3.97236 |
| 65 02 36 | 244 59 44 | Dorchester Heights | 6456.5 | 3.81000 |
| 134 15 15 | 314 12 52 | Powderhorn. | 6762.4 | 3.83010 |
| 201 59 27 | 22 00 12 | Powderhorn | 4104.8 | 3.61329 |
| 297 00 24 | 117 01 59 | Governor's Island. | 3601.2 | 3.55645 |
| 223 07 36 | 43 10 17 | Powderhorn | 7995.2 | 3.90283 |
| 289 48 56 | 109 51 07 | Dorcester Heights. | 4747.4 | 3.67646 |
| 63 16 21 | 243 13 43 | Boston State House | 6013.3 | 3.77911 |
| 128 10 07 | 308 08 49 | Powderhorn. | 3364.7 | 3.52694 |
| 208 40 14 | 28 41 04 | Powderhorn | 3541.9 | 3.54924 |
| 304 41 40 | 124 43 19 | Governor's Island. | 4100.0 | 3.61278 |

**BOSTON BAY—Continued.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Bird Island. | 42 21 22.80 | 703.4 | 71 01 15.97 | 365.5 |
| Bird Island Beacon. | 42 21 18.06 | 557.2 | 71 01 15.96 | 365.3 |
| Navy-yard chimney. | 42 22 30.04 | 926.9 | 71 03 09.16 | 209.6 |
| Apple Island, flag. | 42 21 31.55 | 973.5 | 70 59 32.43 | 742.1 |
| Bluff Head, flag. | 42 22 03.82 | 117.9 | 70 58 04.53 | 103.6 |
| Lewis' wharf, cupola. | 42 21 47.44 | 1463.8 | 71 03 00.02 | 0.5 |
| Faneuil Hall. | 42 21 36.38 | 1122.4 | 71 03 23.70 | 542.4 |
| Bunker Hill Monument. | 42 22 35.05 | 1081.4 | 71 03 40.56 | 927.9 |
| Bunker Hill, Catholic church, cross. | 42 22 53.34 | 1645.7 | 71 04 00.70 | 16.0 |
| Green Island, flag. | 42 21 11.17 | 344.6 | 70 53 33.01 | 755.5 |
| Green Island 2. 1860. | 42 21 11.14 | 343.7 | 70 53 33.02 | 755.7 |
| McLean's Asylum, north dome. | 42 22 37.26 | 1149.7 | 71 04 54.68 | 1250.9 |
| Watertown, United States arsenal, flag. | 42 21 42.72 | 1318.1 | 71 09 45.97 | 1051.9 |
| Cushing's (J. P.) house, skylight. | 42 22 48.57 | 1498.6 | 71 10 10.24 | 234.2 |
| Breed's Island. | 42 23 28.04 | 865.2 | 71 00 30.28 | 692.6 |
| State-street block. | 42 21 33.64 | 1038.0 | 71 03 08.13 | 186.0 |
| Prospect Somerville. | 42 22 54.62 | 1685.3 | 71 05 37.88 | 866.6 |
| Waverly House. | 42 22 17.56 | 541.8 | 71 03 46.42 | 1062.1 |
| Fitchburg Depot. | 42 22 00.36 | 11.1 | 71 03 41.64 | 952.8 |
| Lowell Round House. | 42 22 09.74 | 300.5 | 71 04 23.39 | 535.2 |
| Lowell Draw, flagstaff. | 42 22 05.14 | 158.6 | 71 04 08.40 | 192.2 |
| Lowell Depot, flagstaff. | 42 21 53.81 | 1660.3 | 71 03 47.12 | 1078.2 |
| Organ Factory. | 42 21 44.45 | 1371.5 | 71 04 58.17 | 1331.1 |

**BOSTON BAY—Continued.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 93 24 16 | 273 22 32 | Boston State House | 3555. 2 | 3. 55086 |
| 155 24 18 | 335 23 40 | East Boston. | 3065. 6 | 3. 48651 |
| 11 16 52 | 191 16 40 | South Boston Point | 2046. 3 | 3. 31096 |
| 38 46 46 | 218 45 54 | Blind Asylum. | 2810. 7 | 3. 44882 |
| 122 48 05 | 302 45 20 | Tuft's College | 6656. 7 | 8. 82326 |
| 130 41 06 | 310 39 41 | Ten Hill Farm 2. | 3808. 4 | 3. 58074 |
| 288 34 24 | 108 35 46 | Deer Island | 2932. 2 | 3. 46719 |
| 57 05 29 | 237 03 25 | Dorchester Heights. | 5003. 3 | 3. 69926 |
| 323 51 53 | 143 54 24 | Nantasket | 8713. 4 | 3. 94019 |
| 59 08 37 | 239 05 34 | Dorchester Heights. | 7237. 4 | 3. 85958 |
| 200 10 00 | 20 10 46 | Powderhorn | 4511. 5 | 3. 65432 |
| 290 30 07 | 110 31 42 | Governor's Island. | 3445. 2 | 3. 53722 |
| 204 37 00 | 24 38 02 | Powderhorn | 5033. 7 | 3. 70189 |
| 282 55 34 | 102 57 25 | Governor's Island. | 3867. 1 | 3. 58738 |
| 221 54 21 | 41 55 34 | Powderhorn | 3716. 8 | 3. 57017 |
| 302 46 31 | 122 48 33 | Governor's Island. | 4941. 4 | 3. 69385 |
| 123 09 36 | 303 07 26 | Tuft's College | 5276. 8 | 3. 72237 |
| 270 23 39 | 90 24 54 | East Boston Reservoir. | 2536. 5 | 3. 40424 |
| 11 17 25 | 191 16 53 | Nantasket | 5521. 2 | 3. 74203 |
| 86 49 02 | 266 46 22 | Deer Island. | 5455. 3 | 3. 73682 |
| 11 17 26 | 191 16 54 | Nantasket | 5520. 3 | 3. 74196 |
| 115 10 34 | 295 04 57 | Powderhorn. | 12609. 6 | 4. 10070 |
| 191 39 48 | 11 40 26 | Waite 1 | 6413. 6 | 3. 80710 |
| 237 08 18 | 57 10 21 | Powderhorn. | 4973. 5 | 3. 69666 |
| 247 57 29 | 68 02 48 | Powderhorn | 11693. 9 | 4. 06796 |
| 287 14 53 | 107 19 43 | Dorchester Heights. | 10309. 3 | 4. 01323 |
| 258 18 34 | 78 24 10 | Powderhorn | 11635. 6 | 4. 06579 |
| 324 54 20 | 144 55 46 | Corey. | 5097. 4 | 3. 70735 |
| 308 27 30 | 128 29 06 | Winthrop Head 2 | 4150. 0 | 3. 61805 |
| 121 04 34 | 301 03 39 | Powderhorn. | 2183. 5 | 3. 33915 |
| 282 48 12 | 102 49 51 | Governor's Island 3 | 3450. 0 | 3. 53782 |
| 343 11 42 | 163 12 06 | Blind Asylum. | 2791. 4 | 3. 44582 |
| 247 18 24 | 67 20 56 | Powderhorn 2 | 5598. 1 | 3. 74804 |
| 256 52 16 | 76 54 05 | Naval Hospital. | 3803. 4 | 3. 58017 |
| 209 55 13 | 29 55 47 | Naval Hospital | 2314. 9 | 3. 36454 |
| 293 57 00 | 113 58 01 | East Boston Elevator. | 2276. 5 | 3. 35726 |
| 213 10 52 | 33 12 06 | Powderhorn 2 | 4579. 2 | 3. 66079 |
| 281 18 00 | 101 18 58 | East Boston Elevator. | 2009. 6 | 3. 30312 |
| 224 19 13 | 44 20 55 | Powderhorn 2 | 4953. 6 | 3. 69492 |
| 302 53 11 | 122 54 02 | State Street Block. | 2051. 0 | 3. 31197 |
| 232 42 17 | 52 42 31 | Waverly House | 632. 1 | 2. 80076 |
| 283 31 40 | 103 31 58 | Fitchburg Depot. | 630. 1 | 2. 79943 |
| 275 13 09 | 95 14 11 | East Boston Elevator | 2104. 8 | 3. 32322 |
| 304 53 26 | 124 53 52 | State Street Block. | 1088. 1 | 3. 03665 |
| 238 06 08 | 58 06 56 | Waverly House | 1933. 3 | 3. 28630 |
| 254 19 55 | 74 20 47 | Fitchburg Depot. | 1819. 0 | 3. 25982 |

**BOSTON BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Nealy's house. | 42 21 22.37 | 690.2 | 71 06 27.13 | 620.9 |
| Otter street. | 42 21 21.48 | 662.8 | 71 04 24.90 | 569.9 |
| Standard Sugar Refinery. | 42 20 44.00 | 1357.6 | 71 03 15.58 | 356.6 |
| South Boston sea-wall. | 42 21 18.40 | 567.7 | 71 02 43.48 | 995.1 |
| Point Curve. | 42 21 14.02 | 432.6 | 71 02 56.28 | 1288.0 |
| Center. | 42 21 09.74 | 300.5 | 71 02 46.38 | 1061.5 |
| Two-story house, smoke-pipe. | 42 20 56.31 | 1737.5 | 71 05 52.96 | 1212.2 |
| Powers & Melville's elevator, southwest gable. | 42 22 59.03 | 1821.5 | 71 04 40.01 | 915.3 |
| Coal shed, flagstaff. | 42 23 06.56 | 202.4 | 71 02 39.20 | 896.7 |
| Octagonal building. | 42 21 37.37 | 1153.0 | 71 04 19.02 | 435.3 |
| Shed, upper gable. | 42 21 57.42 | 1771.7 | 71 04 11.87 | 271.6 |
| Iron smoke-stack. | 42 23 14.06 | 433.8 | 71 02 26.10 | 597.0 |
| Glass Works, east gable of main building. | 42 22 22.65 | 698.9 | 71 04 41.86 | 957.8 |
| New England Glass Company's chimney. | 42 22 21.35 | 658.8 | 71 04 40.31 | 922.3 |
| Peck's chimney. | 42 22 51.09 | 1576.4 | 71 03 03.64 | 83.3 |
| Fitchburg Round House, flagstaff. | 42 22 23.43 | 722.9 | 71 04 10.02 | 229.3 |
| Round building, ventilator. | 42 20 50.28 | 1551.4 | 71 03 27.19 | 622.4 |
| Round brick building, iron rod. | 42 23 14.81 | 457.0 | 71 04 29.82 | 682.4 |
| Brick factory. | 42 23 45.12 | 1392.2 | 71 04 12.89 | 294.8 |
| Marine Hospital, flagstaff. | 42 23 21.22 | 654.8 | 71 02 43.70 | 999.6 |
| Winslow's factory, corner. | 42 23 02.22 | 685.0 | 71 03 53.96 | 1234.4 |
| Holmes' factory. | 42 22 45.76 | 1412.0 | 71 03 29.36 | 671.7 |
| Crossing, signal pole. | 42 22 27.27 | 841.4 | 71 04 15.52 | 355.1 |

**BOSTON BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 201 35 37 | 21 36 10 | Prospect Somerville | 3061.2 | 3.48589 |
| 251 28 54 | 71 29 54 | Organ Factory. | 2146.9 | 3.33182 |
| 90 34 20 | 270 32 58 | Nealy's House | 2797.6 | 3.44679 |
| 181 20 39 | 1 20 40 | Lowell Round House. | 1489.8 | 3.17314 |
| 186 21 28 | 6 21 33 | State Street Block | 1541.1 | 3.18782 |
| 319 23 35 | 139 24 04 | Blind Asylum. | 1502.2 | 3.17674 |
| 215 23 57 | 35 24 16 | East Boston Elevator | 1104.8 | 3.04330 |
| 276 00 32 | 96 01 54 | Governor's Island 3. | 2815.8 | 3.44960 |
| 155 51 41 | 335 51 33 | State Street Block | 663.2 | 2.82161 |
| 245 12 19 | 65 12 28 | South Boston sea-wall. | 322.4 | 2.50846 |
| 120 16 50 | 300 16 43 | Point Curve | 262.1 | 2.41849 |
| 193 56 28 | 13 56 30 | South Boston sea-wall. | 275.5 | 2.44011 |
| 135 47 35 | 315 47 12 | Nealy's House | 1121.6 | 3.04985 |
| 220 09 43 | 40 10 20 | Organ Factory. | 1944.0 | 3.28870 |
| 316 13 35 | 136 14 11 | Waverly House | 1771.8 | 3.24841 |
| 345 56 58 | 165 57 09 | Lowell Round House. | 1567.6 | 3.19524 |
| 302 48 49 | 122 49 09 | East Boston Reservoir 2 | 797.5 | 2.90175 |
| 142 13 40 | 322 13 29 | Naval Hospital. | 625.5 | 2.79625 |
| 103 42 42 | 283 42 16 | Organ Factory | 922.4 | 2.96492 |
| 174 17 53 | 354 17 50 | Lowell Round House. | 1003.8 | 3.00166 |
| 69 19 23 | 249 18 52 | Organ Factory | 1132.8 | 3.05415 |
| 145 16 59 | 325 16 51 | Lowell Round House. | 462.6 | 2.66516 |
| 330 49 39 | 150 49 50 | East Boston Reservoir 2 | 760.0 | 2.88082 |
| 51 23 24 | 231 23 04 | Chelsea Bridge. | 865.8 | 2.93740 |
| 277 03 24 | 97 04 01 | Waverly House | 1278.0 | 3.10652 |
| 296 30 27 | 116 31 08 | Fitchburg Depot. | 1540.1 | 3.18755 |
| 54 13 31 | 234 11 15 | Corey | 5696.1 | 3.75558 |
| 230 21 08 | 50 23 02 | Powderhorn. | 4998.7 | 3.69886 |
| 215 49 48 | 35 50 36 | Powderhorn 2 | 2796.5 | 3.44661 |
| 190 15 36 | 10 15 41 | Naval Hospital. | 987.7 | 2.99462 |
| 288 33 03 | 108 33 19 | Waverly House | 569.1 | 2.75517 |
| 35 53 55 | 215 53 46 | Lowell Round House. | 521.3 | 2.71708 |
| 198 03 40 | 18 03 53 | State Street Block | 1407.5 | 3.14844 |
| 261 24 53 | 81 26 45 | Governor's Island 3. | 3843.7 | 3.58475 |
| 246 56 18 | 66 58 04 | Powderhorn 2 | 3921.3 | 3.59343 |
| 282 05 40 | 102 07 14 | East Boston Reservoir 2. | 3273.6 | 3.51502 |
| 259 26 14 | 79 27 49 | Powderhorn 2 | 3276.2 | 3.51537 |
| 299 57 14 | 119 58 37 | East Boston Reservoir 2. | 3247.3 | 3.51152 |
| 221 26 38 | 41 27 13 | Powderhorn 2 | 1784.3 | 3.25146 |
| 318 50 05 | 138 50 28 | East Boston Reservoir 2. | 1174.6 | 3.06990 |
| 235 23 09 | 55 24 31 | Powderhorn 2 | 3387.5 | 3.52988 |
| 277 07 37 | 97 08 47 | East Boston Reservoir 2. | 2399.1 | 3.38005 |
| 213 55 07 | 33 55 29 | Naval Hospital | 1369.5 | 3.13656 |
| 222 27 37 | 42 28 43 | Powderhorn 2. | 3296.3 | 3.51803 |
| 294 13 42 | 114 14 02 | Waverly House | 729.8 | 2.86319 |
| 18 22 53 | 198 22 48 | Lowell Round House. | 569.8 | 2.75573 |

**BOSTON BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Gambrel roof, northeast gable. | 42 22 18.38 | 567.1 | 71 03 26.45 | 605.2 |
| Tudor cupola. | 42 22 14.98 | 462.2 | 71 03 39.81 | 910.9 |
| Gray's wharf, long brick building, northeast corner. | 42 22 09.48 | 292.5 | 71 03 16.38 | 374.8 |
| Prince street draw-tender's house, pole. | 42 22 07.79 | 240.4 | 71 03 35.91 | 821.7 |
| Draw, northwest corner, iron crane. | 42 22 05.92 | 182.7 | 71 03 56.41 | 1290.7 |
| Car-shed, northeast ventilator. | 42 22 09.94 | 306.7 | 71 04 00.51 | 11.7 |
| One-story red building, southwest end. | 42 22 07.93 | 244.7 | 71 04 17.38 | 397.7 |
| National dock building, southeast corner. | 42 22 02.92 | 90.1 | 71 02 33.56 | 767.9 |
| Long wharf building, lightning rod. | 42 21 37.08 | 1144.1 | 71 02 57.46 | 1314.9 |
| Cunard wharf, flagstaff. | 42 21 50.08 | 1545.8 | 71 02 26.90 | 615.5 |
| Cunard wharf, flagstaff, 1877. | 42 21 49.98 | 1542.2 | 71 02 27.98 | 640.3 |
| Cunard wharf, pole, 1860. | 42 21 50.37 | 1554.2 | 71 02 29.04 | 664.5 |
| Fawn Beacon. | 42 21 17.58 | 542.4 | 70 56 32.87 | 752.5 |
| Deer Island Beacon. | 42 20 23.44 | 723.2 | 70 57 18.41 | 421.4 |
| Deer Island Hospital, cupola. | 42 21 12.39 | 382.3 | 70 57 53.15 | 1216.4 |
| Deer Island flag, 1860. | 42 21 01.24 | 38.3 | 70 57 30.95 | 708.4 |
| Lincoln's wharf, post. | 42 21 57.72 | 1781.0 | 71 02 58.15 | 1330.6 |
| Eastern avenue wharf, post. | 42 21 50.10 | 1545.9 | 71 02 56.18 | 1285.6 |
| Loring's machine shop, wharf. | 42 20 31.60 | 975.0 | 71 02 02.70 | 61.8 |
| Foster's wharf, post. | 42 21 21.15 | 652.6 | 71 03 01.36 | 31.1 |
| South Bay Tripod. | 42 19 31.09 | 959.3 | 71 03 46.58 | 1066.6 |
| Prentice's coal wharf, post. | 42 21 08.76 | 270.3 | 71 03 11.58 | 265.0 |
| Sailor's Home, cupola. | 42 21 19.10 | 589.3 | 71 03 08.40 | 192.2 |

**BOSTON BAY—Continued.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 32 00 48 | 212 00 38 | Fitchburg Depot | 655.4 | 2.81649 |
| 86 49 48 | 266 49 35 | Waverly House. | 457.9 | 2.66076 |
| 5 16 56 | 185 16 55 | Fitchburg Depot | 452.8 | 2.65594 |
| 117 41 06 | 297 41 02 | Waverly House. | 171.1 | 2.23314 |
| 64 02 03 | 244 01 46 | Fitchburg Depot | 642.7 | 2.80803 |
| 109 54 20 | 289 54 00 | Waverly House. | 731.3 | 2.86409 |
| 29 45 18 | 209 45 14 | Fitchburg Depot | 263.9 | 2.42143 |
| 141 22 23 | 321 22 16 | Waverly House. | 385.7 | 2.58620 |
| 212 26 57 | 32 27 04 | Waverly House | 425.6 | 2.62898 |
| 296 51 29 | 116 51 39 | Fitchburg Depot. | 379.0 | 2.57869 |
| 233 54 38 | 53 54 47 | Waverly House | 398.8 | 2.60072 |
| 304 22 06 | 124 22 19 | Fitchburg Depot. | 523.4 | 2.71887 |
| 247 14 31 | 67 14 52 | Waverly House | 767.9 | 2.88528 |
| 285 55 18 | 105 55 42 | Fitchburg Depot. | 850.6 | 2.92970 |
| 9 23 06 | 189 22 59 | South Boston sea-wall | 1392.4 | 3.14376 |
| 41 11 24 | 221 11 01 | State Street Block. | 1201.0 | 3.07954 |
| 330 58 35 | 150 58 44 | South Boston sea-wall | 659.1 | 2.81894 |
| 66 27 19 | 246 27 12 | State Street Block. | 266.3 | 2.42540 |
| 297 33 28 | 117 34 41 | Governor's Island | 2784.7 | 3.44478 |
| 3 35 13 | 183 35 07 | Dorchester Heights. | 3297.2 | 3.51815 |
| 20 00 27 | 200 00 17 | South Boston sea-wall | 1036.9 | 3.01574 |
| 61 13 56 | 241 13 29 | State Street Block. | 1048.0 | 3.02035 |
| 337 02 08 | 157 02 45 | South Boston Point | 3262.1 | 3.51350 |
| 1 34 18 | 181 34 15 | Blind Asylum. | 3189.6 | 3.50374 |
| 203 41 31 | 23 43 02 | Nahant 2 | 7657.0 | 3.88406 |
| 331 33 28 | 151 34 57 | Nantasket. | 6382.0 | 3.80496 |
| 106 47 40 | 286 45 25 | Governor's Island | 4796.2 | 3.68090 |
| 166 08 48 | 346 08 40 | Deer Island. | 1202.4 | 3.08006 |
| 134 14 04 | 314 11 23 | Powderhorn | 7624.1 | 3.88219 |
| 214 24 06 | 34 26 31 | Nahant 2. | 8693.2 | 3.93918 |
| 133 29 12 | 313 26 16 | Powderhorn | 8228.9 | 3.91534 |
| 210 21 58 | 30 24 08 | Nahant 2. | 8711.6 | 3.94010 |
| 201 06 28 | 21 07 13 | Powderhorn | 4199.4 | 3.62319 |
| 350 22 35 | 170 22 52 | Blind Asylum. | 3464.0 | 3.53958 |
| 199 27 40 | 19 28 23 | Powderhorn | 4404.3 | 3.64388 |
| 350 28 12 | 170 28 28 | Blind Asylum. | 3224.6 | 3.50848 |
| 42 19 59 | 222 19 39 | Blind Asylum | 1025.2 | 3.01082 |
| 237 39 07 | 57 40 01 | Governor's Island 2. | 2163.0 | 3.33506 |
| 276 40 45 | 96 42 18 | Governor's Island 2 | 3191.8 | 3.50403 |
| 344 04 37 | 164 04 56 | Blind Asylum. | 2378.0 | 3.37622 |
| 178 23 53 | 358 23 50 | Boston State House | 3658.0 | 3.56324 |
| 236 40 43 | 56 41 33 | Blind Asylum. | 2019.5 | 3.30525 |
| 269 48 30 | 89 50 10 | Governor's Island 2 | 3403.7 | 3.53195 |
| 306 00 41 | 126 01 27 | Loring's machine shop. | 1949.4 | 3.28989 |
| 275 16 49 | 95 18 27 | Governor's Island 2 | 3345.2 | 3.52442 |
| 339 54 17 | 159 54 41 | Blind Asylum. | 2367.7 | 3.37432 |

**BOSTON BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Boylston School, cupola. | 42 21 21.51 | 663.7 | 71 03 09.02 | 206.4 |
| Fort Hill wharf, post. | 42 21 15.74 | 485.7 | 71 03 05.16 | 118.1 |
| Central wharf, cupola. | 42 21 32.54 | 1004.0 | 71 03 05.21 | 119.2 |
| India wharf, cupola. | 42 21 29.10 | 897.9 | 71 02 59.70 | 1366.2 |
| India wharf, post. | 42 21 28.04 | 865.2 | 71 02 59.09 | 1352.2 |
| Grand Junction wharf, shears. | 42 21 47.39 | 1462.2 | 71 02 22.93 | 524.7 |
| Bay State Iron Works, north gable. | 42 20 24.77 | 764.3 | 71 02 22.31 | 510.7 |
| Bay State Steam-Engine Works, wharf post. | 42 21 45.52 | 1404.5 | 71 02 09.69 | 221.7 |
| Adams' School, flagstaff. | 42 21 57.86 | 1785.2 | 71 01 59.08 | 1351.9 |
| Hog Island tripod. | 42 23 30.16 | 930.6 | 71 00 39.69 | 907.8 |
| Gas works, north end of Boston, chimney. | 42 22 01.90 | 58.6 | 71 03 28.38 | 649.4 |
| Gas Works, near Malden Bridge, chimney. | 42 23 18.75 | 578.5 | 71 04 29.70 | 679.4 |
| Miller's River, head of, church. | 42 22 44.08 | 1360.1 | 71 05 48.79 | 1116.2 |
| Carpet-cleaning factory, ventilator. | 42 21 16.62 | 512.8 | 71 04 39.93 | 913.9 |
| Mill-dam, yellow house, chimney. | 42 20 56.22 | 1734.7 | 71 05 51.67 | 1182.7 |
| Mill-dam, regatta house, flagstaff. | 42 21 04.89 | 150.9 | 71 05 19.01 | 435.1 |
| Planing mill, chimney. | 42 22 16.17 | 498.9 | 71 07 17.17 | 392.9 |
| Varnish factory, chimney. | 42 21 49.54 | 1528.6 | 71 07 06.33 | 144.9 |
| Riverside Press, chimney. | 42 21 46.03 | 1420.2 | 71 06 57.05 | 1305.5 |
| Charles River tripod. | 42 21 09.41 | 290.3 | 71 07 00.28 | 6.4 |
| Small red house on marsh, chimney. | 42 24 45.88 | 1415.6 | 71 06 07.72 | 176.5 |
| Cloverden. | 42 22 47.54 | 1466.9 | 71 07 18.42 | 421.4 |
| Cloverden Observatory, astronomical latitude station (zenith telescope), 1855 and 1864. | 42 22 46.29 | 1428.3 | 71 07 17.60 | 402.6 |

**BOSTON BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 340 11 10 | 160 11 34 | Blind Asylum | 2442.5 | 3.38783 |
| 314 00 08 | 134 01 12 | South Boston Point. | 3041.7 | 3.48311 |
| 273 35 38 | 93 37 14 | Governor's Island 2 | 3263.2 | 3.51364 |
| 313 36 22 | 133 37 04 | Loring's machine shop. | 1974.7 | 3.29549 |
| 322 43 43 | 142 44 25 | Loring's machine shop | 2362.9 | 3.37344 |
| 344 19 19 | 164 19 41 | Blind Asylum. | 2740.4 | 3.43781 |
| 319 55 36 | 139 56 34 | South Boston Point | 3067.1 | 3.48673 |
| 346 21 24 | 166 21 42 | Blind Asylum. | 2605.4 | 3.41587 |
| 319 44 02 | 139 45 00 | South Boston Point | 3033.1 | 3.48189 |
| 346 29 22 | 166 29 40 | Blind Asylum. | 2570.4 | 3.41000 |
| 338 44 39 | 158 45 12 | South Boston Point | 3124.4 | 3.49476 |
| 4 12 02 | 184 11 55 | Blind Asylum. | 3104.9 | 3.49205 |
| 153 44 39 | 333 44 08 | State Street Block | 2369.7 | 3.37470 |
| 239 34 19 | 59 35 27 | Governor's Island 3. | 2685.7 | 3.42906 |
| 343 47 22 | 163 47 46 | South Boston Point | 2972.1 | 3.47306 |
| 9 54 10 | 189 53 54 | Blind Asylum. | 3084.6 | 3.48920 |
| 349 43 14 | 169 43 31 | South Boston Point | 3287.4 | 3.51685 |
| 12 44 48 | 192 44 25 | Blind Asylum. | 3505.7 | 3.54477 |
| 60 46 02 | 240 45 01 | East Boston Reservoir | 2363.0 | 3.37346 |
| 122 46 44 | 302 45 55 | Powderhorn. | 1967.3 | 3.29387 |
| 66 28 25 | 246 25 21 | Corey | 6836.0 | 3.83480 |
| 92 15 59 | 272 12 29 | Mount Auburn. | 7144.1 | 3.85395 |
| 133 06 00 | 313 05 29 | Ten Hill Farm 2 | 1433.2 | 3.15630 |
| 284 03 28 | 104 05 02 | East Boston Reservoir. | 3298.5 | 3.51832 |
| 245 18 43 | 65 21 23 | Powderhorn | 5959.4 | 3.77520 |
| 75 25 20 | 255 23 24 | Mount Auburn. | 4056.4 | 3.60814 |
| 73 56 29 | 253 54 13 | Corey | 4818.3 | 3.68289 |
| 106 57 54 | 286 55 12 | Mount Auburn. | 5751.9 | 3.75981 |
| 120 51 39 | 300 49 45 | Mount Auburn | 4496.7 | 3.65289 |
| 163 52 18 | 343 51 23 | Tuft's College. | 6765.5 | 3.83030 |
| 75 25 22 | 255 23 32 | Corey | 3859.8 | 3.58657 |
| 113 52 40 | 293 50 24 | Mount Auburn. | 5038.6 | 3.70231 |
| 17 59 52 | 197 59 22 | Corey | 3334.7 | 3.52306 |
| 181 04 15 | 1 04 17 | Tuft's College. | 4032.7 | 3.60560 |
| 28 33 18 | 208 32 40 | Corey | 2675.3 | 3.42738 |
| 107 04 15 | 287 03 12 | Mount Auburn. | 2250.8 | 3.35234 |
| 33 37 59 | 213 37 15 | Corey | 2692.3 | 3.43012 |
| 173 34 21 | 355 34 10 | Tuft's College. | 4976.8 | 3.69695 |
| 129 39 54 | 309 38 47 | Mount Auburn | 2974.9 | 3.47347 |
| 177 05 02 | 357 04 53 | Tuft's College. | 6099.7 | 3.78531 |
| 325 01 36 | 145 02 11 | Ten Hill Farm 2 | 2086.0 | 3.31932 |
| 68 46 32 | 248 45 47 | Tuft's College. | 1622.4 | 3.21017 |
| 249 00 39 | 69 01 37 | Somerville church, 1860 | 2106.2 | 3.32350 |
| 107 30 10 | 287 29 53 | Cambridge Observatory. | 610.7 | 2.78582 |
| 154 01.1 | 334 01.1 | Cloverden | 42.98 | 1.63323 |

**BOSTON BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Agassiz Museum. | 42 22 44.52 | 1373.7 | 71 06 56.04 | 1282.0 |
| Gould's Transitory, 1865. | 42 22 41.01 | 1265.4 | 71 06 57.87 | 1323.8 |
| Boston, Hollis street church. | 42 20 59.42 | 1833.3 | 71 03 53.15 | 1216.4 |
| Boston, Hanover street brick church. | 42 21 49.90 | 1539.6 | 71 03 17.44 | 399.1 |
| Boston, St. Mary's church, north spire. | 42 21 54.82 | 1691.5 | 71 03 29.69 | 679.4 |
| Boston Neck, dark spire with clock. | 42 20 26.77 | 826.0 | 71 04 25.27 | 578.5 |
| Boston, Catholic cathedral, statue. | 42 20 12.67 | 390.9 | 71 04 25.14 | 575.5 |
| Boston, Berkley street, yellow spire. | 42 20 44.13 | 1361.6 | 71 04 15.42 | 353.0 |
| Boston jail, cupola. | 42 21 43.26 | 1334.5 | 71 04 14.44 | 330.4 |
| Boston, State prison, cupola. | 42 22 28.23 | 871.0 | 71 04 08.84 | 202.2 |
| Boston light-house (C. & G. S. & B.), 1834–'47. | 42 19 40.74 | 1257.0 | 70 53 26.18 | 599.4 |
| South Boston flats, A. | 42 20 21.44 | 661.5 | 71 01 39.28 | 899.1 |
| South Boston flats, B. | 42 20 21.59 | 666.2 | 71 02 14.82 | 339.3 |
| South Boston flats, C. | 42 20 15.97 | 492.8 | 71 02 35.44 | 811.3 |
| South Boston flats, D. | 42 20 30.32 | 935.5 | 71 03 06.10 | 139.6 |
| South Boston flats, E. | 42 20 34.38 | 1060.7 | 71 03 15.65 | 358.2 |
| South Boston Reservoir. | 42 19 58.48 | 1804.4 | 71 02 46.56 | 1066.0 |
| South Boston, dark spire with turrets, cross. | 42 20 31.87 | 983.3 | 71 03 24.44 | 559.5 |
| West Boston bridge, pole on draw. | 42 21 41.49 | 1280.2 | 71 04 26.12 | 597.7 |
| Charlestown, brick church, cross. | 42 22 21.96 | 677.6 | 71 03 48.32 | 1105.5 |
| Outer Brewster. | 42 20 29.40 | 907.2 | 70 52 41.16 | 942.1 |
| Outer Brewster 2. 1860. | 42 20 29.33 | 905.0 | 70 52 41.21 | 943.3 |
| Brighton, east church. | 42 20 57.83 | 1784.3 | 71 09 13.03 | 298.3 |

**BOSTON BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 239 46 25 | 59 47 08 | Somerville church, 1860 | 1683.3 | 3.22610 |
| 104 11 43 | 284 11 11 | Cambridge Observatory. | 1128.9 | 3.05264 |
| 201 09 | 21 09 | Agassiz Museum | 116.2 | 2.06534 |
| | | | | |
| 266 26 51 | 86 29 02 | Governor's Island | 4451.1 | 3.64847 |
| 314 19 47 | 134 20 39 | Dorchester Heights. | 2471.9 | 3.39303 |
| 289 28 50 | 109 30 37 | Governor's Island | 3845.5 | 3.58495 |
| 343 51 41 | 163 52 09 | Dorchester Heights | 3420.1 | 3.53404 |
| 209 08 56 | 29 10 02 | Powderhorn 2 | 4584.2 | 3.66126 |
| 277 28 18 | 97 29 08 | East Boston Elevator. | 1711.9 | 3.23349 |
| 332 43 11 | 152 43 37 | South Bay Tripod | 1933.0 | 3.28623 |
| 118 51 24 | 298 48 32 | Mount Auburn. | 6664.4 | 3.82376 |
| 273 51 19 | 93 52 35 | Blind Asylum | 2576.3 | 3.41100 |
| 325 27 19 | 145 27 45 | South Bay Tripod. | 1557.4 | 3.19241 |
| 343 40 01 | 163 40 20 | South Bay Tripod | 2348.4 | 3.37078 |
| 86 21 40 | 266 19 07 | Corey. | 5201.6 | 3.71614 |
| 67 33 03 | 247 30 30. | Corey | 5641.1 | 3.75136 |
| 98 00 50 | 277 57 51 | Mount Auburn. | 6144.7 | 3.78850 |
| 130 52 14 | 310 50 09 | Tuft's College | 5594.7 | 3.74778 |
| 149 01 56 | 329 01 11 | Ten Hill Farm 2. | 2959.9 | 3.47128 |
| 125 10 34 | 305 04 53 | Powderhorn | 14152.5 | 4.150832 |
| 173 12 42 | 353 12 07 | Nahant. | 10068.1 | 4.002949 |
| 273 07 09 | 93 07 45 | Castle Island | 1229.4 | 3.08969 |
| 223 37 47 | 43 38 28 | Governor's Island. | 1998.4 | 3.30068 |
| 133 37 36 | 313 36 31 | Boston State House | 3041.9 | 3.48314 |
| 236 40 03 | 56 41 08 | Governor's Island. | 2624.2 | 3.41900 |
| 142 42 44 | 322 41 53 | Boston State House | 2855.8 | 3.45573 |
| 238 46 04 | 58 47 22 | Governor's Island. | 3115.9 | 3.49359 |
| 150 39 04 | 330 38 34 | Boston State House | 2098.4 | 3.32188 |
| 250 47 13 | 70 48 52 | Governor's Island. | 3564.7 | 3.55202 |
| 154 34 42 | 334 34 18 | Boston State House | 1886.5 | 3.27566 |
| 253 42 12 | 73 43 58 | Governor's Island. | 3734.7 | 3.57226 |
| 58 23 19 | 238 22 39 | South Bay Tripod | 1613.4 | 3.20775 |
| 188 52 41 | 8 53 06 | East Boston Reservoir. | 5443.0 | 3.73584 |
| 252 43 28 | 72 45 17 | Governor's Island 2 | 3872.8 | 3.58802 |
| 15 06 56 | 195 06 41 | South Bay Tripod. | 1942.5 | 3.28837 |
| 66 59 46 | 246 57 20 | Corey | 5373.7 | 3.73027 |
| 98 54 04 | 278 51 13 | Mount Auburn. | 5888.4 | 3.77000 |
| 219 59 52 | 40 01 10 | Powderhorn | 4138.0 | 3.61679 |
| 247 07 33 | 67 08 39 | East Boston Reservoir. | 2445.1 | 3.38830 |
| 28 48 29 | 208 47 22 | Nantasket | 4708.4 | 3.67287 |
| 98 28 05 | 278 24 50 | Deer Island. | 6706.4 | 3.82649 |
| 117 51 07 | 297 44 56 | Powderhorn | 14246.9 | 4.15372 |
| 165 21 30 | 345 20 25 | Nahant 2. | 8785.0 | 3.94374 |
| 240 12 54 | 60 17 51 | Powderhorn | 11620.9 | 4.06524 |
| 280 25 27 | 100 29 54 | Dorchester Heights. | 9244.0 | 3.96586 |

BOSTON BAY—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Brighton, west church, with clock. | 42 20 56.25 | 1735.5 | 71 09 20.29 | 464.4 |
| North Brighton, dark spire. | 42 21 13.69 | 422.4 | 71 08 12.35 | 282.6 |
| Moon Head 1. | 42 18 22.20 | 684.9 | 70 59 23.06 | 528.1 |
| Moon Head 2. 1860. | 42 18 22.04 | 680.0 | 70 59 23.13 | 529.8 |
| Weeks' house, chimney. | 42 20 21.21 | 654.4 | 70 53 49.02 | 1122.2 |
| Weeks' barn, center chimney. | 42 20 23.48 | 724.5 | 70 53 52.86 | 1210.1 |
| Kimbal's house, center chimney. | 42 20 19.12 | 590.0 | 20 53 26.75 | 612.4 |
| Machine-shop, tall chimney on ridge pole. | 42 20 28.60 | 882.5 | 71 03 59.10 | 1352.9 |
| Gas Works, ventilator. | 42 20 50.28 | 1551.4 | 71 03 27.18 | 622.1 |
| Fulton Wire Works, south chimney. | 42 20 08.04 | 248.1 | 71 03 29.56 | 676.7 |
| Lawrence School, cupola. | 42 20 28.78 | 888.0 | 71 03 12.88 | 294.8 |
| Railroad tripod. | 42 20 52.37 | 1615.9 | 21 02 57.82 | 1323.5 |
| James and Pope's timber dock, post. | 42 20 32.51 | 1003.1 | 71 02 39.68 | 908.3 |
| Fort Independence, flagstaff, 1861. | 42 20 18.90 | 583.2 | 71 00 44.92 | 1028.3 |
| George's Island. | 42 19 11.16 | 344.3 | 70 55 42.32 | 969.1 |
| Barrel Beacon. | 42 19 22.27 | 687.1 | 70 55 09.18 | 210.2 |
| Brookline, Dr. Pierce's church. | 42 19 38.18 | 1178.0 | 71 07 52.48 | 1201.5 |
| Gallop Island, flag. | 42 19 37.30 | 1150.9 | 70 56 21.48 | 491.7 |
| Gallop Island 2. 1860. | 42 19 37.97 | 1171.5 | 70 56 23.16 | 530.3 |
| Lovel's Island, pole. | 42 19 48.60 | 1499.4 | 70 55 50.36 | 1152.9 |
| Nix's Mate. | 42 19 53.55 | 1652.2 | 70 56 40.94 | 937.2 |
| Sargent's observatory. | 42 18 42.75 | 1319.0 | 71 05 41.40 | 948.1 |
| Roxbury, Jamaica Plains, tall church spire. | 42 18 36.44 | 1124.3 | 71 06 59.36 | 1359.4 |

**BOSTON BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 240 24 36 | 60 29 39 | Powderhorn | 11789.6 | 4.07150 |
| 291 32 25 | 111 33 18 | Corey. | 1921.8 | 3.28371 |
| 160 03 03 | 340 02 44 | Mount Auburn | 1879.4 | 3.27402 |
| 349 25 19 | 169 25 26 | Corey. | 1265.3 | 3.10221 |
| 307 35 18 | 27 36 33 | Deer Island | 5538.9 | 3.74342 |
| 271 37 45 | 91 41 09 | Nantasket. | 6939.7 | 3.84134 |
| 162 09 04 | 342 07 24 | Powderhorn | 11107.8 | 4.04563 |
| 271 35 23 | 91 38 47 | Nantasket. | 6941.3 | 3.84144 |
| 10 26 44 | 190 26 23 | Nantasket | 3938.2 | 3.59530 |
| 64 21 41 | 244 17 56 | Moon Head 2. | 8488.3 | 3.92882 |
| 9 01 20 | 189 01 02 | Nantasket | 3992.4 | 3.60123 |
| 63 40 25 | 243 36 43 | Moon Head 2. | 8440.0 | 3.92634 |
| 17 49 11 | 197 48 35 | Nantasket | 4000.3 | 3.60209 |
| 121 05 47 | 301 00 06 | Powderhorn. | 13494.3 | 4.13015 |
| 288 37 06 | 108 38 04 | Blind Asylum | 2083.1 | 3.31872 |
| 350 49 29 | 170 49 37 | South Bay Tripod. | 1797.5 | 3.25468 |
| 261 12 23 | 81 14 14 | Governor's Island 2 | 3805.2 | 3.58038 |
| 10 18 00 | 190 17 47 | South Bay Tripod. | 2483.6 | 3.39508 |
| 271 21 22 | 91 22 00 | Blind Asylum | 1298.3 | 3.11338 |
| 18 52 08 | 198 51 57 | South Bay Tripod. | 1204.8 | 3.08090 |
| 250 03 59 | 70 05 40 | Governor's Island 2 | 3652.2 | 3.56256 |
| 23 25 56 | 203 25 33 | South Bay Tripod. | 1939.9 | 3.28778 |
| 260 29 57 | 80 31 28 | Governor's Island 2 | 3131.8 | 3.49579 |
| 337 46 47 | 157 47 04 | Blind Asylum. | 1511.0 | 3.17926 |
| 271 53 30 | 91 53 55 | Loring's machine shop | 847.0 | 2.92790 |
| 348 45 22 | 168 45 27 | Blind Asylum. | 801.3 | 2.90380 |
| 80 43 26 | 260 42 53 | South Boston Point | 1125.8 | 3.05145 |
| 157 44 51 | 337 43 54 | East Boston Reservoir. | 5129.7 | 3.71009 |
| 312 17 29 | 132 18 24 | Nantasket | 2542.8 | 3.40531 |
| 21 10 17 | 201 09 20 | Great Quincy. | 5364.3 | 3.72951 |
| 237 30 32 | 57 31 29 | Great Brewster | 2280.0 | 3.35793 |
| 331 21 57 | 151 22 30 | Nantasket. | 2340.4 | 3.36929 |
| 172 33 44 | 352 33 37 | Corey | 1717.7 | 3.23495 |
| 225 03 19 | 45 07 22 | Powderhorn. | 11647.4 | 4.06623 |
| 148 27 02 | 328 26 15 | Deer Island | 3040.9 | 3.48300 |
| 257 59 01 | 78 00 46 | Great Brewster. | 3658.6 | 3.56331 |
| 312 01 34 | 132 02 57 | Nantasket | 3791.1 | 3.57877 |
| 60 24 12 | 240 22 11 | Moon Head 2. | 4740.8 | 3.67585 |
| 132 14 23 | 314 13 15 | Deer Island | 3214.9 | 3.50717 |
| 261 48 27 | 81 49 51 | Great Brewster. | 2895.6 | 3.46174 |
| 266 17 44 | 86 19 42 | Great Brewster | 4032.3 | 3.60555 |
| 313 07 28 | 133 09 03 | Nantasket. | 4416.0 | 3.64503 |
| 136 39 04 | 316 37 29 | Corey | 4695.4 | 3.67167 |
| 239 36 20 | 59 38 25 | Dorchester Heights. | 4923.1 | 3.69224 |
| 158 15 58 | 338 15 16 | Corey | 3884.5 | 3.58933 |
| 263 46 33 | 83 47 25 | Sargent's Observatory. | 1796.1 | 3.25434 |

**BOSTON BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Roxbury, laboratory, chimney. | 42 19 24.52 | 756.5 | 71 05 52.98 | 1213.1 |
| Roxbury, Dr. Putnam's church. | 42 19 47.81 | 1475.1 | 71 05 24.96 | 571.4 |
| Roxbury, new Unitarian church. | 42 19 42.11 | 1299.2 | 71 04 51.72 | 1184.1 |
| Roxbury Oil Works, chimney. | 42 19 55.40 | 1709.4 | 71 03 55.14 | 1262.4 |
| Spectacle Island, flag. | 42 19 38.90 | 1200.3 | 70 59 16.66 | 381.4 |
| Squantum. | 42 18 13.89 | 428.7 | 71 00 41.57 | 952.1 |
| Thompson's Island, flag. | 42 19 14.60 | 450.5 | 71 00 16.12 | 369.2 |
| Thompson's Island, pole near farm school. | 42 19 07.56 | 233.3 | 71 00 26.01 | 595.6 |
| Thompson's Island 2. 1860. | 42 19 07.88 | 243.1 | 71 00 25.65 | 587.4 |
| Long Island, south end, flag. | 42 18 39.52 | 1219.4 | 70 58 37.16 | 851.0 |
| Long Island, south end 2. 1860. | 42 18 39.60 | 1221.9 | 70 58 36.88 | 844.6 |
| Long Island Hotel, cupola. | 42 19 27.40 | 845.4 | 70 57 53.39 | 1222.5 |
| Farm school-house, southeast gable. | 42 19 05.26 | 162.3 | 71 00 27.55 | 630.9 |
| Fort Warren, west gable of house. | 42 19 13.10 | 404.2 | 70 55 42.40 | 970.9 |
| Flagstaff, corner Dorchester street and turnpike. | 42 19 47.62 | 1469.3 | 71 03 26.50 | 606.7 |
| Suffolk Cordage Factory, ball. | 42 19 38.04 | 1173.7 | 71 04 20.24 | 463.4 |
| Point Allerton, flag. | 42 18 37.12 | 1145.3 | 70 52 59.36 | 1359.4 |
| Point Allerton beacon, 1860. | 42 18 47.08 | 1452.6 | 70 53 00.29 | 6.6 |
| Commercial Point wharf, flag. | 42 18 00.28 | 8.6 | 71 02 38.24 | 875.9 |
| Dorchester, Dr. Codman's church. | 42 17 26.85 | 828.4 | 71 04 18.00 | 412.4 |
| Dorchester, church with clock. | 42 18 29.60 | 913.3 | 71 03 45.81 | 1049.2 |
| Summer-house on hill. | 42 18 09.13 | 281.8 | 71 04 35.65 | 816.6 |
| North Pettick Island. | 42 18 06.28 | 193.8 | 70 55 47.57 | 1089.6 |

**BOSTON BAY—Continued.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 212 30 40 | 32 33 22 | Powderhorn | 10253.4 | 4.01087 |
| 255 04 54 | 75 07 07 | Dorchester Heights. | 4669.0 | 3.66922 |
| 111 20 56 | 291 19 10 | Corey | 3864.5 | 3.58709 |
| 211 33 50 | 31 36 14 | Powderhorn. | 9304.2 | 3.96868 |
| 109 57 24 | 289 55 16 | Corey | 4639.0 | 3.66642 |
| 258 02 18 | 78 03 49 | Dorchester Heights. | 3178.2 | 3.50218 |
| 259 11 56 | 79 12 51 | Blind Asylum | 1917.6 | 3.28275 |
| 345 20 51 | 165 20 57 | South Bay Tripod. | 775.3 | 2.88946 |
| 99 26 00 | 279 23 46 | Dorchester Heights | 4623.3 | 3.66501 |
| 145 38 57 | 235 38 02 | Governor's Island. | 3341.4 | 3.52393 |
| 142 14 36 | 322 13 19 | Dorchester Heights | 4275.0 | 3.63094 |
| 269 36 06 | 89 40 23 | Nantasket. | 8735.3 | 3.94128 |
| 115 13 04 | 295 11 30 | Dorchester Heights | 3537.4 | 3.54868 |
| 171 30 00 | 351 29 45 | Governor's Island. | 3547.4 | 3.54991 |
| 12 08 47 | 192 08 37 | Squantum | 1693.5 | 3.22879 |
| 120 06 31 | 300 05 04 | Dorchester Heights. | 3437.6 | 3.53626 |
| 167 49 45 | 347 48 47 | Powderhorn | 9368.7 | 3.97168 |
| 280 51 22 | 100 55 28 | Nantasket. | 8522.8 | 3.93058 |
| 199 05 54 | 19 06 39 | Deer Island | 4629.0 | 3.66549 |
| 277 05 50 | 97 08 43 | Nantasket. | 5931.0 | 3.77313 |
| 156 01 13 | 335 59 02 | Powderhorn | 10979.4 | 4.04058 |
| 206 26 25 | 26 29 19 | Nahant 2. | 13276.4 | 4.12308 |
| 147 28 37 | 327 25 56 | Powderhorn | 10149.9 | 4.00646 |
| 205 16 44 | 25 19 09 | Nahant 2. | 11514.9 | 4.06126 |
| 168 11 30 | 348 10 33 | Powderhorn | 9438.9 | 3.97492 |
| 280 16 09 | 100 20 16 | Nantasket. | 8551.1 | 3.93202 |
| 313 15 05 | 133 16 00 | Nantasket | 2584.8 | 3.41242 |
| 72 42 46 | 252 40 17 | Moon Head 2. | 5295.0 | 3.72387 |
| 42 03 44 | 222 03 30 | South Bay Tripod. | 686.4 | 2.83660 |
| 243 58 08 | 63 58 44 | Blind Asylum. | 1366.5 | 3.13560 |
| 249 59 19 | 70 00 31 | Blind Asylum | 2616.3 | 3.41769 |
| 285 31 53 | 105 32 16 | South Bay Tripod. | 800.2 | 2.90318 |
| 70 21 32 | 250 20 38 | Nantasket | 1965.9 | 3.29357 |
| 158 10 17 | 338 09 46 | Great Brewster. | 2820.1 | 3.45026 |
| 85 00 04 | 264 55 46 | Moon Head 2 | 8802.0 | 3.94458 |
| 128 53 46 | 308 47 48 | Powderhorn. | 15623.9 | 4.19379 |
| 180 48 11 | 0 48 13 | Dorchester Heights | 3800.1 | 3.57979 |
| 261 03 06 | 81 04 25 | Squantum. | 2705.1 | 3.43219 |
| 205 48 41 | 25 49 50 | Dorchester Heights | 5367.0 | 3.72973 |
| 253 39 28 | 73 41 54 | Squantum. | 5165.6 | 3.71312 |
| 208 55 54 | 28 56 41 | Dorchester Heights | 3308.0 | 3.51956 |
| 276 32 06 | 96 34 10 | Squantum. | 4247.5 | 3.62813 |
| 217 51 19 | 37 52 40 | Dorchester Heights | 4467.0 | 3.65002 |
| 268 24 26 | 88 27 04 | Squantum. | 5363.6 | 3.72946 |
| 261 44 14 | 81 45 13 | Nantasket | 2022.2 | 3.30582 |
| 156 19 52 | 336 18 42 | Deer Island. | 5896.0 | 3.77056 |

**BOSTON BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| North Pettick Island 2. 1860. | 42 18 06.32 | 195.0 | 70 55 47.73 | 1093.3 |
| South Pettick Island. | 42 17 23.82 | 735.0 | 70 56 51.66 | 1183.5 |
| Rainsford Island, flagstaff. 1846. | 42 18 46.83 | 1444.9 | 70 57 07.41 | 169.7 |
| Rainsford Island flag, 1860. | 42 18 46.91 | 1447.4 | 70 57 07.12 | 16.3 |
| Hull, Oregon House, cupola. | 42 18 12.14 | 374.6 | 70 54 47.44 | 1086.6 |
| Hull, Steamboat Hotel, cupola. | 42 18 16.26 | 501.7 | 70 55 08.29 | 189.9 |
| Strawberry Hill, barn. | 42 17 22.52 | 694.8 | 70 52 49.47 | 1133.4 |
| Neponset church. | 42 17 11.62 | 358.5 | 71 07 52.87 | 1211.3 |
| Hangman's Ledge Beacon. | 42 17 44.75 | 1380.8 | 70 57 39.22 | 898.4 |
| Forbes. | 42 15 27.87 | 859.9 | 71 01 38.94 | 892.5 |
| Crow Point. | 42 15 41.98 | 1295.3 | 70 53 46.47 | 1065.1 |
| Sagamore Head. | 42 16 24.46 | 754.7 | 70 51 50.04 | 1146.6 |
| Turkey Hill. | 42 14 25.68 | 792.4 | 70 51 14.22 | 326.0 |
| Eaton's Hill, flag. | 42 15 44.08 | 1360.0 | 70 59 53.43 | 1224.5 |
| Parker's Hill. | 42 13 45.60 | 1406.9 | 70 46 49.45 | 1133.8 |
| Paine's Hill observatory. | 42 14 01.56 | 48.2 | 70 59 42.96 | 985.1 |
| Thayer's Hill, yellow house, chimney. | 42 13 51.49 | 1588.7 | 70 58 10.55 | 241.9 |
| Bunkin Island, flag. | 42 16 51.86 | 1600.1 | 70 54 02.85 | 65.3 |
| Black Rock. | 42 16 08.56 | 264.1 | 70 49 28.42 | 651.3 |
| Grape Island, flag. | 42 16 07.28 | 224.4 | 70 55 27.21 | 623.6 |
| Baker's Hill. | 42 14 35.94 | 1108.9 | 70 54 28.47 | 652.7 |
| Hingham, church with clock. | 42 14 34.32 | 1058.9 | 70 53 29.43 | 674.7 |
| Hingham, old church. | 42 14 26.68 | 884.9 | 70 53 14.96 | 343.0 |

BOSTON BAY—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 95 38 01 | 275 35 36 | Moon Head 2 | 4957.5 | 3.69526 |
| 143 01 03 | 322 56 58 | Powderhorn. | 13848.4 | 4.14140 |
| 117 22 37 | 297 20 55 | Moon Head 2 | 3905.4 | 3.59167 |
| 193 50 21 | 13 52 04 | Nahant 2. | 14651.1 | 4.16587 |
| 172 35 15 | 352 34 59 | Deer Island | 4183.6 | 3.62155 |
| 284 04 03 | 104 05 55 | Nantasket. | 3948.2 | 3.59640 |
| 76 10 22 | 256 08 50 | Moon Head 2 | 3208.2 | 3.50626 |
| 146 24 19 | 326 21 07 | Powderhorn. | 11774.7 | 4.07095 |
| 138 15 57 | 318 11 11 | Powderhorn | 14585.8 | 4.16393 |
| 182 59 34 | 2 59 54 | Nahant 2. | 12750.0 | 4.10551 |
| 91 46 25 | 271 43 34 | Moon Head 2 | 5839.7 | 3.76639 |
| 139 21 34 | 319 17 02 | Powderhorn. | 14175.6 | 4.15154 |
| 74 23 16 | 254 20 23 | Great Quincy | 6124.2 | 3.78705 |
| 128 17 29 | 308 16 28 | Nantasket. | 2648.3 | 3.42297 |
| 184 11 19 | 4 11 30 | Dorchester Heights | 5315.3 | 3.72553 |
| 237 24 42 | 57 26 10 | Squantum. | 3569.3 | 3.55258 |
| 122 13 42 | 302 10 22 | Dorchester Heights | 8029.7 | 3.90470 |
| 181 46 36 | 1 46 42 | Deer Island. | 6066.7 | 3.78295 |
| 171 16 48 | 351 16 10 | Dorchester Heights | 8602.4 | 3.93462 |
| 242 42 23 | 62 47 18 | Nantasket. | 11308.4 | 4.05340 |
| 52 06 28 | 232 03 11 | White's Hill | 8510.8 | 3.92997 |
| 107 33 39 | 287 31 24 | Great Quincy. | 4817.0 | 3.68278 |
| 91 08 35 | 271 05 02 | Great Quincy | 7261.6 | 3.86102 |
| 134 56 45 | 314 55 04 | Nantasket. | 4859.7 | 3.68660 |
| 74 18 26 | 254 13 27 | White's Hill | 10604.0 | 4.02547 |
| 149 02 02 | 328 59 57 | Nantasket. | 8277.9 | 3.91792 |
| 238 28 21 | 58 32 05 | Nantasket | 8953.9 | 3.95201 |
| 342 11 42 | 162 12 32 | White's Hill. | 5561.1 | 3.74516 |
| 57 38 54 | 237 35 47 | Prospect Hingham | 7542.9 | 3.87754 |
| 102 09 14 | 282 07 12 | Scituate. | 4263.4 | 3.62976 |
| 218 09 50 | 38 11 35 | Great Quincy | 5788.6 | 3.76257 |
| 325 35 44 | 145 36 27 | White's Hill. | 2583.7 | 3.41224 |
| 196 42 21 | 16 43 04 | Great Quincy | 5075.2 | 3.70545 |
| 266 22 55 | 86 28 31 | Scituate. | 11471.5 | 4.05962 |
| 80 31 42 | 260 29 38 | Great Quincy | 4275.2 | 3.63096 |
| 171 15 41 | 351 15 29 | Nantasket. | 2617.0 | 3.41780 |
| 93 29 04 | 273 23 56 | Great Quincy | 10525.0 | 4.02222 |
| 120 25 58 | 300 22 42 | Nantasket. | 7751.0 | 3.88936 |
| 201 10 25 | 21 11 10 | Nantasket | 4249.1 | 3.62830 |
| 263 54 08 | 83 56 34 | Sagamore Head. | 5005.0 | 3.69940 |
| 133 52 31 | 314 50 44 | Great Quincy | 5035.6 | 3.70205 |
| 181 36 04 | 1 36 10 | Nantasket. | 6782.7 | 3.83140 |
| 125 23 58 | 305 21 32 | Great Quincy | 6112.7 | 3.78623 |
| 213 49 45 | 33 50 52 | Sagamore Head. | 4090.9 | 3.61182 |
| 124 57 22 | 304 54 46 | Great Quincy | 6484.1 | 3.81185 |
| 162 17 38 | 342 17 17 | Crow Point. | 2373.6 | 3.37541 |

**BOSTON BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Hingham, Old Colony House, cupola. | 42 14 51.75 | 1596.7 | 70 52 22.62 | 518.5 |
| Hingham, Great Plain church. | 42 12 38.35 | 1183.2 | 70 53 04.50 | 103.2 |
| Milton, old church. | 42 15 12.35 | 381.0 | 71 04 50.38 | 1154.8 |
| Milton Mills, tall church spire. | 42 16 26.49 | 817.3 | 71 04 07.96 | 182.4 |
| Wellington Hill, flag. | 42 16 59.24 | 1827.8 | 71 05 44.08 | 1010.0 |
| Atlantic House, chimney. | 42 16 03.02 | 93.3 | 70 50 53.05 | 1215.7 |
| Rockland House, cupola. | 42 15 56.90 | 1755.5 | 70 51 10.05 | 230.3 |
| Pig Rock Beacon. | 42 16 44.04 | 1358.8 | 70 56 22.65 | 519.0 |
| Quincy, Bent's Point church. | 42 14 45.75 | 1411.6 | 70 58 31.97 | 732.9 |
| Quincy, stone church. | 42 15 04.25 | 131.1 | 71 00 12.98 | 297.5 |
| Quincy, black top church. | 42 15 00.66 | 20.4 | 70 59 49.90 | 1143.8 |
| Minot's Ledge light-house, 1847–'77. | 42 16 11.16 | 344.3 | 70 45 34.71 | 795.4 |
| Cohasset church. | 42 14 35.63 | 1099.3 | 70 48 14.02 | 321.4 |
| Weymouth Great Hill, flag. | 42 14 59.38 | 1832.1 | 70 56 33.50 | 767.8 |
| North Weymouth church. | 42 13 46.46 | 1433.4 | 70 56 42.94 | 984.6 |
| East Weymouth church. | 42 12 50.40 | 1555.0 | 70 55 31.08 | 712.9 |
| King Oak Hill, pole. | 42 13 38.94 | 1201.4 | 70 56 25.32 | 580.6 |

**FROM CAPE COD BAY TO BOSTON BAY.**

| | | | | |
|---|---|---|---|---|
| Monk's Hill (C. & G. S. & B.). | 41 57 39.108 | 1206.7 | 70 43 23.398 | 538.8 |
| Carolina Hill. | 42 06 58.520 | 1805.4 | 70 43 52.853 | 1214.2 |
| Prospect Hingham (C. & G. S. & B.). | 42 11 34.686 | 1070.2 | 70 51 27.166 | 623.3 |
| Sprague (C. & G. S. & B.). | 42 00 17.896 | 552.2 | 70 58 00.109 | 2.5 |

**BOSTON BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 128 52 51 | 308 51 55 | Crow Point | 2469.3 | 3.39257 |
| 194 37 39 | 14 38 01 | Sagamore Head. | 2956.2 | 3.47073 |
| 236 08 45 | 56 10 55 | Scituate | 5336.1 | 3.72722 |
| 311 19 53 | 131 20 58 | Prospect Hingham. | 2973.9 | 3.47332 |
| 156 05 43 | 336 03 34 | Corey | 10836.3 | 4.03488 |
| 198 55 06 | 18 56 37 | Dorchester Heights. | 9494.9 | 3.97749 |
| 197 28 34 | 17 29 36 | Dorchester Heights | 7017.3 | 3.84617 |
| 234 57 19 | 54 59 38 | Squantum. | 5774.3 | 3.76150 |
| 154 25 49 | 334 24 16 | Corey | 7325.5 | 3.86484 |
| 217 09 14 | 37 11 21 | Dorchester Heights. | 7132.3 | 3.85323 |
| 95 23 14 | 275 19 03 | Great Quincy | 8604.4 | 3.93472 |
| 130 47 57 | 310 45 38 | Nantasket. | 6267.6 | 3.79710 |
| 330 11 22 | 150 12 15 | Scituate | 3635.6 | 3.56058 |
| 1 57 01 | 181 56 58 | Turkey Hill. | 2816.4 | 3.44970 |
| 168 51 04 | 348 50 18 | Deer Island | 8090.0 | 3.90795 |
| 224 45 27 | 44 46 49 | Nantasket. | 3983.3 | 3.60024 |
| 221 39 51 | 41 42 40 | Nantasket | 8674.0 | 3.93822 |
| 301 08 21 | 121 13 07 | Prospect Hingham. | 11387.5 | 4.05643 |
| 233 48 32 | 53 52 29 | Nantasket | 10012.0 | 4.00052 |
| 298 09 03 | 118 14 56 | Prospect Hingham. | 13683.3 | 4.13619 |
| 233 51 57 | 53 53 47 | Great Quincy | 4625.6 | 3.66517 |
| 337 44 08 | 157 44 55 | White's Hill. | 4273.8 | 3.63081 |
| 58 34 57 | 238 32 05 | Scituate | 6892.1 | 3.838352 |
| 107 44 55 | 287 39 03 | Nantasket. | 12637.7 | 4.101667 |
| 247 40 10 | 67 41 27 | Ocean House | 2822.2 | 3.45059 |
| 300 37 12 | 120 39 09 | Cat Hill. | 4629.0 | 3.66549 |
| 206 44 50 | 26 46 20 | Nantasket | 6783.6 | 3.83146 |
| 311 55 34 | 131 59 00 | Prospect Hingham. | 9447.1 | 3.97530 |
| 58 02 11 | 238 00 53 | White's Hill | 3145.9 | 3.49775 |
| 173 45 40 | 353 45 24 | Great Quincy. | 5045.8 | 3.70293 |
| 189 11 15 | 9 12 03 | Nantasket | 10167.6 | 4.00722 |
| 292 38 11 | 112 40 55 | Prospect Hingham. | 6063.9 | 3.78275 |
| 64 59 51 | 244 58 21 | White's Hill | 3390.7 | 3.53029 |
| 169 43 06 | 349 42 38 | Great Quincy. | 5334.0 | 3.72705 |

**FROM CAPE COD BAY TO BOSTON BAY.**

| | | | | |
|---|---|---|---|---|
| 288 41 59.6 | 108 47 17.3 | Manomet | 11560.9 | 4.062992 |
| 130 53 24.9 | 310 37 40.4 | Blue Hill. | 42760.3 | 4.631041 |
| 357 44 58.0 | 177 45 17.7 | Monk's Hill | 17273.1 | 4.237371 |
| 108 43 33.0 | 288 28 06.8 | Blue Hill. | 33418.6 | 4.523988 |
| 309 12 12.3 | 129 17 17.2 | Carolina Hill | 13468.5 | 4.129319 |
| 95 50 00.1 | 275 39 38.4 | Blue Hill. | 21339.0 | 4.329175 |
| 283 33 45.4 | 103 43 31.8 | Monk's Hill | 20768.8 | 4.317410 |
| 152 03 25.9 | 331 57 28.8 | Blue Hill. | 26068.1 | 4.416109 |

**FROM CAPE COD BAY TO BOSTON BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Gurnet. | 42 00 11.398 | 351.7 | 70 36 06.055 | 139.4 |
| Brant. | 42 05 17.319 | 534.4 | 70 38 28.702 | 659.7 |
| White. | 42 07 05.938 | 183.2 | 70 41 24.595 | 565.0 |
| Alden (Borden). | 41 49 48.328 | 1491.1 | 70 57 02.790 | 64.4 |
| Telegraph Hill (Borden). | 42 06 53.638 | 1654.9 | 70 41 50.218 | 1153.6 |
| Scituate light-house (C. & G. S. & B.)., 1834–1849. | 42 12 17.316 | 534.3 | 70 42 58.736 | 1347.4 |
| Standish. | 42 00 50.77 | 1566.4 | 70 40 58.21 | 1339.4 |
| Standish monument. | 42 00 50.24 | 1550.0 | 70 40 57.66 | 1326.7 |
| Plymouth. | 41 57 24.78 | 764.5 | 70 40 07.93 | 182.6 |
| Plymouth Pier Head. | 41 58 46.50 | 1434.6 | 70 39 13.38 | 308.0 |
| Plymouth Court-House (Borden), 1835. | 41 57 26.37 | 813.5 | 70 40 02.23 | 51.4 |
| Plymouth National Monument. | 41 57 36.69 | 1132.0 | 70 40 34.87 | 803.0 |
| Plymouth (Gurnet) light-house (Borden), 1835. | 42 00 12.10 | 373.3 | 70 36 04.33 | 99.6 |
| Plymouth (Gurnet) light-house, 1848–1870. | 42 00 12 30 | 379.5 | 70 36 04.03 | 92.7 |
| North Plymouth Rope Works. | 41 58 47.50 | 1465.5 | 70 41 20.16 | 464.1 |
| Kingston. | 41 58 53.29 | 1644.1 | 70 41 54.63 | 1257.6 |
| Kingston spire. | 41 59 36.08 | 1113.2 | 70 43 52.77 | 1214.6 |
| East Duxbury belfry. | 42 02 08.10 | 249.9 | 70 40 24.05 | 553.2 |
| West Duxbury Unitarian steeple. | 42 02 06.65 | 205.2 | 70 41 33.44 | 769.2 |
| Duxbury, astronomical longitude station, transit, 1869–1870. | 42 02 55.18 | 1702.5 | 70 40 10.96 | 252.1 |
| Duxbury Pier light-house, 1877. | 41 59 14.94 | 461.0 | 70 38 56.57 | 1302.2 |
| Powder Point. | 42 02 49.15 | 1516.4 | 70 39 10.75 | 247.2 |
| Eel River steeple. | 41 56 15.18 | 468.3 | 70 37 49.12 | 1131.6 |

**FROM CAPE COD BAY TO BOSTON BAY—Continued.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 65 01 23.1 | 244 56 30.6 | Monk's Hill | 11110.6 | 4.045737 |
| 139 31 49.6 | 319 26 36.9 | Carolina Hill. | 16522.3 | 4.218069 |
| 346 52 48.7 | 166 54 49.5 | Manomet | 18329.6 | 4.263152 |
| 25 38 52.9 | 205 35 35.6 | Monk's Hill. | 15679.0 | 4.195317 |
| 338 49 17.8 | 158 53 16.4 | Manomet | 22734.4 | 4.356683 |
| 8 53 29.3 | 188 52 09.7 | Monk's Hill. | 17700.8 | 4.247994 |
| 249 58 27.9 | 70 12 52.2 | Manomet | 31749.7 | 4.501739 |
| 232 21 54.6 | 52 31 01.8 | Monk's Hill. | 23827.8 | 4.377083 |
| 337 04 39.9 | 157 08 55.7 | Manomet | 22603.6 | 4.354178 |
| 7 08 55.9 | 187 07 53.5 | Monk's Hill. | 17242.9 | 4.236610 |
| 347 18 50.1 | 167 19 53.3 | White | 9847.4 | 3.993321 |
| 110 58 42.6 | 290 54 05.4 | Scituate. | 10129.5 | 4.005586 |
| 280 12 52 | 100 16 08 | Gurnet | 6831.7 | 3.83453 |
| 321 41 01 | 141 44 42 | Manomet. | 12266.5 | 4.08872 |
| 321 40 59 | 141 44 39 | Manomet | 12245.9 | 4.08799 |
| 29 38 55 | 209 37 18 | Monk's Hill. | 6784.7 | 3.83153 |
| 227 15 55 | 47 18 37 | Gurnet | 7578.4 | 3.87958 |
| 95 37 36 | 275 35 25 | Monk's Hill. | 4523.1 | 3.65544 |
| 318 08 22 | 138 10 53 | Manomet | 7777.5 | 3.89084 |
| 238 42 27 | 58 44 32 | Gurnet. | 5045.1 | 3.70287 |
| 297 43 29 | 117 46 32 | Manomet | 7134.8 | 3.85338 |
| 171 55 58 | 351 54 46 | Telegraph Hill. | 17677.5 | 4.24742 |
| 297 13 46 | 117 17 11 | Manomet | 7948.2 | 3.90027 |
| 91 07 04 | 271 05 11 | Monk's Hill. | 3881.8 | 3.58903 |
| 354 21 10 | 174 21 34 | Manomet | 8476.6 | 3.92822 |
| 65 00 30 | 244 55 36 | Monk's Hill. | 11155.8 | 4.04750 |
| 354 24 32 | 174 24 56 | Manomet | 8482.2 | 3.92851 |
| 64 59 38 | 244 54 44 | Monk's Hill. | 11164.0 | 4.04782 |
| 305 39 47 | 125 43 43 | Manomet | 9983.4 | 3.99928 |
| 250 16 20 | 70 19 50 | Gurnet. | 7679.4 | 3.88533 |
| 303 57 44 | 124 02 02 | Manomet | 10737.2 | 4.03089 |
| 253 15 01 | 73 18 54 | Gurnet. | 8377.4 | 3.92311 |
| 264 09 52 | 84 15 04 | Gurnet | 10796.7 | 4.03329 |
| 349 23 13 | 169 23 33 | Monk's Hill. | 3672.0 | 3.56490 |
| 330 25 04 | 150 28 22 | Manomet | 13811.5 | 4.14024 |
| 26 27 35 | 206 25 35 | Monk's Hill. | 9269.2 | 3.96704 |
| 324 52 26 | 144 56 30 | Manomet | 14628.8 | 4.16521 |
| 17 03 18 | 197 02 05 | Monk's Hill. | 8633.6 | 3.93619 |
| 334 10 20 | 154 13 29 | Manomet | 14957.9 | 4.17487 |
| 51 43 52 | 231 42 57 | West Duxbury Unitarian steeple. | 2416.6 | 3.38320 |
| 324 14 45 | 144 17 04 | Manomet | 8219.2 | 3.91483 |
| 64 19 24 | 244 16 26 | Monk's Hill. | 6818.0 | 3.83366 |
| 158 47 31 | 338 46 01 | White | 8499.4 | 3.92939 |
| 191 56 15 | 11 56 43 | Brant. | 4672.5 | 3.66955 |
| 198 01 36 | 18 02 45 | Gurnet | 7664.8 | 3.88450 |
| 108 37 14 | 288 33 31 | Monk's Hill. | 8123.3 | 3.90973 |

**FROM CAPE COD BAY TO BOSTON BAY—Continued.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Webster's flagstaff. | 42 04 39.21 | 1209.8 | 70 40 13.77 | 316.5 |
| Webster's (Hon. Daniel) house, west chimney. | 42 04 48.26 | 1489.0 | 70 40 47.07 | 1081.9 |
| Lewis. | 42 08 09.45 | 291.6 | 70 43 13.69 | 314.4 |
| Hatch. | 42 08 08.48 | 261.6 | 70 42 11.36 | 260.9 |
| Third Cliff. | 42 10 49.78 | 1536.0 | 70 43 01.94 | 44.5 |
| Briggs. | 42 10 02.49 | 76.8 | 70 44 57.31 | 1315.5 |
| North Marshfield Unitarian spire. | 42 08 30.15 | 930.2 | 70 44 29.46 | 676.5 |
| Scituate Unitarian church. | 42 12 00.69 | 21.3 | 70 45 22.19 | 509.0 |
| Studley. | 42 08 13.49 | 416.2 | 70 48 07.38 | 168.5 |
| Bonney. | 42 03 10.50 | 324.0 | 70 52 34.01 | 782.1 |
| Coleman. | 42 10 42.14 | 1300.2 | 70 43 38.65 | 887.0 |

**CAPE COD BAY AND PENINSULA.**

| | | | | |
|---|---|---|---|---|
| Provincetown. | 42 03 08.452 | 260.7 | 70 11 20.533 | 472.2 |
| Scargo. | 41 44 22.481 | 693.6 | 70 10 49.824 | 1151.3 |
| Chatham (C. & G. S. & B.). | 41 41 50.705 | 1564.3 | 69 58 48.380 | 1118.7 |
| Mill Hill (C. & G. S. & B.). | 41 46 34.142 | 1053.4 | 70 00 06.967 | 160.7 |
| Griffin's Island. | 41 56 14.374 | 443.4 | 70 04 06.046 | 139.3 |
| Race Point light house, 1877. | 42 03 44.564 | 1374.9 | 70 14 36.989 | 850.4 |
| Long Point light-house, 1877. | 42 01 59.467 | 1834.8 | 70 10 09.008 | 207.2 |
| Wood End light-house, 1877. | 42 01 16.608 | 512.4 | 70 11 38.491 | 885.7 |
| Cape Cod (Highlands of Truro) light-house, 1877. | 42 02 23.165 | 714.7 | 70 03 39.833 | 916.1 |
| Billingsgate light-house, 1868. | 41 52 18.221 | 562.1 | 70 04 09.871 | 227.6 |

**FROM CAPE COD BAY TO BOSTON BAY—Continued.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 338 27 38 | 158 30 49 | Manomet | 17925.9 | 4.25348 |
| 18 37 16 | 198 35 09 | Monk's Hill. | 13676.3 | 4.13597 |
| 168 31 40 | 348 31 15 | White | 4334.8 | 3.63697 |
| 328 55 09 | 148 56 14 | Powder Point. | 4290.9 | 3.63255 |
| 182 34 05 | 2 34 15 | Scituate light-house | 7655.6 | 3.88398 |
| 308 00 48 | 128 02 01 | White. | 3181.0 | 3.50256 |
| 315 53 32 | 135 56 01 | Brant | 7352.4 | 3.86643 |
| 330 53 39 | 150 54 10 | White. | 2208.5 | 3.34410 |
| 3 07 15 | 183 07 07 | Lewis | 4954.6 | 3.69501 |
| 342 03 27 | 162 04 32 | White. | 7259.1 | 3.86088 |
| 241 07 54 | 61 09 11 | Third Cliff | 3023.3 | 3.48048 |
| 325 41 36 | 145 42 45 | Lewis. | 4222.2 | 3.62554 |
| 167 21 18 | 347 20 59 | Briggs | 2920.1 | 3.46540 |
| 204 59 33 | 25 00 32 | Third Cliff. | 4753.7 | 3.67703 |
| 261 07 41 | 81 09 17 | Scituate light-house | 3330.9 | 3.52256 |
| 329 01 24 | 149 04 04 | White. | 10604.5 | 4.02549 |
| 143 33 42 | 323 31 28 | Prospect Hingham | 7717.7 | 3.88749 |
| 208 23 25 | 28 25 16 | Scituate Unitarian church. | 7970.0 | 3.90146 |
| 185 37 46 | 5 38 31 | Prospect Hingham | 15631.8 | 4.19401 |
| 239 31 24 | 59 37 13 | Carolina Hill. | 13891.5 | 4.14275 |
| 197 19 06 | 17 19 33 | Scituate light-house | 3076.0 | 3.48798 |
| 135 34 38 | 315 33 28 | Scituate Unitarian church. | 3393.9 | 3.53070 |

**CAPE COD BAY AND PENINSULA.**

| | | | | |
|---|---|---|---|---|
| 67 31 32.8 | 247 15 24.4 | Manomet | 36095.1 | 4.557448 |
| 17 54 15.3 | 197 47 55.4 | Shootflying. | 42821.5 | 4.631662 |
| 178 50 07.6 | 358 49 47.1 | Provincetown | 34746.5 | 4.540911 |
| 66 35 20.7 | 246 28 41.5 | Shootflying. | 15119.3 | 4.179530 |
| 105 45 02.0 | 285 37 01.9 | Scargo | 17321.8 | 4.238592 |
| 75 04 18.8 | 254 51 15.5 | Hyannis. | 28226.4 | 4.450655 |
| 74 45 44.4 | 254 38 36.3 | Scargo | 15396.6 | 4.187426 |
| 153 13 22.7 | 333 05 52.7 | Provincetown. | 34380.9 | 4.536317 |
| 141 59 15.2 | 321 54 24.5 | Provincetown | 16224.2 | 4.210163 |
| 342 51 22.2 | 162 54 01.7 | Mill Hill. | 18731.8 | 4.272579 |
| 62 37 00.1 | 242 23 03.0 | Manomet | 32465.0 | 4.511415 |
| 11 38 05.1 | 191 33 56.3 | Shootflying. | 42747.2 | 4.630907 |
| 71 34 23.9 | 251 17 27.8 | Manomet | 36893.3 | 4.566947 |
| 20 59 38.6 | 200 52 31.0 | Shootflying. | 41361.8 | 4.616599 |
| 72 33 29.5 | 252 17 33.4 | Manomet | 34527.5 | 4.538165 |
| 18 52 17.5 | 198 46 09.7 | Shootflying. | 39416.5 | 4.595678 |
| 74 19 09.7 | 253 57 53.2 | Manomet | 45668.2 | 4.659614 |
| 31 12 18.1 | 211 00 50.8 | Shootflying. | 45974.5 | 4.662517 |
| 32 12 30.4 | 212 08 03.8 | Scargo | 17340.0 | 4.239050 |
| 332 08 25.9 | 152 11 07.9 | Mill Hill. | 12004.8 | 4.079357 |

**CAPE COD BAY AND PENINSULA**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| German Hill. | 41 41 27.962 | 862.7 | 70 12 35.978 | 832.0 |
| Point Gammon. | 41 37 04.965 | 153.2 | 70 15 39.322 | 910.3 |
| Monomoy. | 41 35 37.602 | 1160.0 | 69 59 03.358 | 77.8 |
| Rock Point. | 41 46 12.951 | 399.5 | 70 04 46.025 | 1063.1 |
| Orleans 2. 1868. | 41 47 32.585 | 1005.4 | 70 00 51.627 | 1191.9 |
| Atwood. | 41 45 11.393 | 351.6 | 70 04 24.315 | 561.7 |
| Hamblin's Hill. | 41 41 49.931 | 1540.4 | 70 24 13.644 | 315.5 |
| Bourne's Hill (C. & G. S. & B.). | 41 44 00.818 | 25.2 | 70 29 11.627 | 268.7 |
| Small's Hill (Borden). | 42 00 35.256 | 1087.8 | 70 02 10.298 | 237.0 |
| Peaked Cliff. | 41 48 31.383 | 968.1 | 70 32 25.060 | 578.5 |
| Holmes. | 41 55 26.564 | 819.5 | 70 32 39.017 | 899.0 |
| Scorton Neck. | 41 44 19.130 | 590.1 | 70 24 41.190 | 951.8 |
| Mount Schaum. | 41 45 25.096 | 774.2 | 70 30 49.984 | 1154.7 |
| Scorton Hill. | 41 43 17.257 | 532.4 | 70 23 41.434 | 957.7 |
| Indian Brook. | 41 51 30.36 | 936.7 | 70 00 23.41 | 539.9 |
| Blackfish Creek. | 41 54 28.86 | 890.4 | 70 01 04.80 | 110.6 |
| Hamblin's Mound. | 41 56 14.18 | 437.5 | 70 02 47.46 | 1093.2 |
| Cambria. | 41 59 14.88 | 459.1 | 70 00 45.13 | 1038.8 |
| Highland. | 42 01 41.33 | 1275.2 | 70 02 47.49 | 1092.4 |
| Pamet. | 42 00 14.91 | 460.0 | 70 04 52.68 | 1212.3 |
| Stout. | 42 04 09.52 | 293.8 | 70 07 32.83 | 754.7 |
| Lombard Head. | 41 55 51.66 | 1593.9 | 69 58 51.02 | 1175.4 |
| Race. | 42 04 50.41 | 1555.3 | 70 12 26.65 | 612.5 |

**CAPE COD BAY AND PENINSULA**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 50 48 53.8 | 230 45 00.7 | Hyannis | 10472.5 | 4.020052 |
| 267 49 25.5 | 87 58 36.0 | Chatham. | 19150.7 | 4.282185 |
| 207 35 10.2 | 27 37 12.1 | German Hill | 9156.0 | 3.961704 |
| 249 15 22.7 | 69 26 34.7 | Chatham. | 24996.8 | 4.397885 |
| 96 45 26.8 | 276 34 25.5 | Point Gammon | 23219.7 | 4.365856 |
| 181 43 24.1 | 1 43 34.1 | Chatham. | 11515.9 | 4.061299 |
| 67 57 38.2 | 247 53 35.9 | Scargo | 9069.5 | 3.957585 |
| 264 10 55.2 | 84 14 01.1 | Mill Hill. | 6478.3 | 3.811459 |
| 65 36 34.1 | 245 33 57.9 | Rock Point | 5944.5 | 3.774116 |
| 330 13 40.1 | 150 14 09.9 | Mill Hill. | 2077.2 | 3.317471 |
| 246 44 03.6 | 66 46 55.0 | Mill Hill | 6469.6 | 3.810878 |
| 80 25 13.7 | 260 20 57.0 | Scargo. | 9034.4 | 3.955902 |
| 312 14 51.6 | 132 18 42.3 | Hyannis | 10849.8 | 4.035423 |
| 255 42 43.2 | 75 51 38.1 | Scargo. | 19167.8 | 4.282573 |
| 158 03 37.6 | 337 59 26.5 | Manomet | 23218.0 | 4.365825 |
| 263 08 42.4 | 83 28 04.2 | Mill Hill. | 40583.2 | 4.608346 |
| 78 56 11.1 | 258 33 55.2 | Manomet | 46903.2 | 4.671202 |
| 353 44 10.1 | 173 45 32.5 | Mill Hill. | 26105.9 | 4.416739 |
| 162 15 35.5 | 342 13 33.3 | Manomet | 13843.3 | 4.141240 |
| 310 23 26.8 | 130 31 09.8 | Shootflying. | 21113.8 | 4.324567 |
| 95 30 15.8 | 275 28 22.8 | Manomet | 3914.5 | 3.592678 |
| 358 33 33.1 | 178 33 42.4 | Peaked Cliff. | 12813.4 | 4.107665 |
| 144 36 32.7 | 324 29 21.2 | Manomet | 25737.7 | 4.410570 |
| 126 02 17.2 | 305 57 08.2 | Peaked Cliff. | 13241.9 | 4.121950 |
| 283 23 55.2 | 103 28 00.8 | Scorton Neck | 8760.8 | 3.942544 |
| 159 06 04.8 | 339 05 01.4 | Peaked Cliff. | 6152.4 | 3.789046 |
| 111 45 18.9 | 291 40 33.6 | Mount Schaum | 10659.6 | 4.027742 |
| 128 45 07.0 | 308 39 18.2 | Peaked Cliff. | 15499.0 | 4.190304 |
| 47 40 05 | 227 33 07 | Scargo | 19580.6 | 4.291826 |
| 149 39 44 | 329 37 15 | Griffin's Island. | 10154.8 | 4.006671 |
| 35 52 16 | 215 45 46 | Scargo | 23071.2 | 4.363070 |
| 127 56 42 | 307 54 41 | Griffin's Island. | 5295.2 | 3.723886 |
| 26 55 23 | 206 50 01 | Scargo | 24616.6 | 4.391228 |
| 137 18 43 | 317 13 00 | Provincetown. | 17401.7 | 4.240591 |
| 357 50 55 | 177 51 20 | Mill Hill | 23487.6 | 4.370839 |
| 116 17 58 | 296 10 53 | Provincetown. | 16299.1 | 4.212164 |
| 102 52 48 | 282 47 05 | Provincetown | 12101.9 | 4.082854 |
| 10 10 23 | 190 09 31 | Griffin's Island. | 10248.5 | 4.010659 |
| 121 00 07 | 300 55 47 | Provincetown | 10405.1 | 4.017248 |
| 227 11 31 | 47 12 55 | Highland. | 3925.1 | 3.593847 |
| 304 50 27 | 124 53 38 | Highland. | 7997.8 | 3.902968 |
| 341 59 52 | 162 02 10 | Griffin's Island. | 15412.7 | 4.187879 |
| 50 21 46 | 230 20 17 | Blackfish Creek | 4003.6 | 3.60245 |
| 95 32 23 | 275 28 53 | Griffin's Island. | 7291.6 | 3.86282 |
| 334 12 03 | 154 12 47 | Provincetown | 3493.9 | 3.54331 |
| 280 33 11 | 100 36 28 | Stout. | 6871.0 | 3.83702 |

**CAPE COD BAY AND PENINSULA**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Truro Congregational spire. | 41 59 54.06 | 1667.9 | 70 03 18.44 | 424.4 |
| Long Point school-house. | 42 01 21.71 | 669.8 | 70 10 55.15 | 1268.8 |
| Long Point light-house, 1847. | 42 01 59.12 | 1824.1 | 70 10 08.87 | 204.0 |
| Race Point light-house, 1835–'47 (C. & G. S. & B.). | 42 03 44.36 | 1368.7 | 70 14 36.98 | 850.2 |
| Mayo's Beach light-house, 1877. | 41 55 49.82 | 1537.2 | 70 02 05.66 | 130.4 |
| Provincetown Methodist Center church. | 42 03 12.55 | 387.2 | 70 11 05.52 | 126.9 |
| Provincetown Methodist Centenary church. | 42 02 52.44 | 1617.9 | 70 11 26.78 | 615.9 |
| Provincetown Baptist church, belfry | 42 03 27.45 | 847.0 | 70 10 39.74 | 913.7 |
| Provincetown old Universalist church, belfry, 1835–'47 (C. & G. S. & B.). | 42 02 51.02 | 1574.2 | 70 11 26.99 | 620.7 |
| Provincetown new Universalist church, spire. | 42 03 02.08 | 64.2 | 70 11 19.94 | 458.5 |
| Provincetown Orthodox church, spire. | 42 03 04.03 | 124.3 | 70 11 17.61 | 405.0 |
| Provincetown Methodist church, belfry. | 42 03 06.52 | 201.2 | 70 11 17.82 | 409.8 |
| Provincetown school-house. | 42 02 41.17 | 1270.2 | 70 11 36.90 | 848.6 |
| Provincetown Academy. | 42 03 09.78 | 301.8 | 70 11 14.50 | 333.4 |
| Cape Cod (Highlands of Truro) light-house (G. and G. S. and B ), 1835–'47. | 42 02 23.18 | 715.2 | 70 03 39.84 | 916.4 |
| North Wellfleet Methodist belfry. | 41 56 19.66 | 606.5 | 70 01 48.95 | 1127.6 |
| North Wellfleet Congregational belfry. | 41 56 09.64 | 297.4 | 70 01 16.48 | 379.7 |
| South Wellfleet Congregational belfry. | 41 54 32.07 | 989.5 | 69 59 07.10 | 163.6 |
| South Wellfleet Methodist meeting-house. | 41 54 24.54 | 757.1 | 69 59 07.72 | 177.9 |
| Billingsgate light-house (C. & G. S. & B.). 1835–'47. | 41 51 38.77 | 1196.1 | 70 04 16.72 | 384.8 |
| Nauset Center light-house, 1846. | 41 51 38.63 | 1191.8 | 69 57 05.42 | 125.0 |
| Eastham Congregational spire. | 41 50 28.28 | 872.5 | 69 58 54.33 | 1253.5 |
| Nauset Harbor. | 41 47 22.72 | 701.0 | 69 56 46.80 | 1080.6 |

**CAPE COD BAY AND PENINSULA**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 106 31 31 | 286 30 28 | Pamet | 2261.8 | 3.35446 |
| 192 08 24 | 12 08 45 | Highland. | 3385.7 | 3.52965 |
| 221 55 45 | 41 58 01 | Stout | 6961.3 | 3.842693 |
| 315 09 21 | 135 13 54 | Griffin's Island. | 13364.8 | 4.125962 |
| 221 42 59 | 41 44 43 | Stout | 5390.7 | 3.73164 |
| 142 23 51 | 322 23 03 | Provincetown. | 2700.2 | 3.43140 |
| 283 45 20 | 103 47 31 | Provincetown | 4650.7 | 3.66751 |
| 235 45 30 | 55 46 57 | Race. | 3623.8 | 3.55917 |
| 350 54 53 | 170 56 12 | Mill Hill | 17361.1 | 4.239578 |
| 29 44 47 | 209 38 57 | Scargo. | 24412.4 | 4.387610 |
| 67 33 07 | 247 16 49 | Manomet | 36462.5 | 4.561846 |
| 18 17 33 | 198 11 03 | Shootflying. | 43049.2 | 4.633965 |
| 68 10 02 | 247 53 58 | Manomet | 35775.7 | 4.553588 |
| 17 55 23 | 197 49 07 | Shootflying. | 42307.4 | 4.626416 |
| 253 10 38 | 73 12 43 | Stout | 4489.3 | 3.652174 |
| 325 49 18 | 145 53 41 | Griffin's Island. | 16144.3 | 4.208018 |
| 245 45 57 | 65 48 34 | Stout | 5904.0 | 3.771144 |
| 320 17 18 | 140 22 13 | Griffin's Island. | 15899.5 | 4.201383 |
| 248 15 14 | 68 17 46 | Stout | 5621.7 | 3.749869 |
| 321 30 48 | 141 35 38 | Griffin's Island. | 16061.2 | 4.205779 |
| 248 37 37 | 68 40 08 | Stout | 5549.1 | 3.744224 |
| 321 47 43 | 141 52 32 | Griffin's Island. | 16075.4 | 4.206162 |
| 249 23 08 | 69 25 39 | Stout | 5526.3 | 3.742436 |
| 321 57 04 | 142 01 53 | Griffin's Island. | 16138.6 | 4.207866 |
| 244 04 18 | 64 07 01 | Stout | 6239.0 | 3.795118 |
| 318 56 58 | 139 02 00 | Griffin's Island. | 15814.8 | 4.199064 |
| 250 05 53 | 70 08 21 | Stout | 5420.1 | 3.734005 |
| 322 23 05 | 142 27 52 | Griffin's Island. | 16171.3 | 4.208745 |
| 97 33 06 | 277 27 57 | Provincetown | 10686.3 | 4.028828 |
| 3 02 01 | 183 01 43 | Griffin's Island. | 11395.2 | 4.056720 |
| 343 25 10 | 163 25 39 | Blackfish Creek | 3566.5 | 3.55224 |
| 87 03 21 | 267 01 49 | Griffin's Island. | 3162.8 | 3.50007 |
| 355 03 18 | 175 03 26 | Blackfish Creek | 3120.7 | 3.49425 |
| 92 09 08 | 272 07 15 | Griffin's Island. | 3909.0 | 3.59207 |
| 87 55 18 | 267 53 59 | Blackfish Creek | 2714.2 | 3.43363 |
| 114 38 28 | 294 35 08 | Griffin's Island. | 7577.3 | 3.87951 |
| 92 50 20 | 272 49 02 | Blackfish Creek | 2701.5 | 3.43161 |
| 116 15 52 | 296 12 33 | Griffin's Island. | 7664.0 | 3.88446 |
| 328 27 18 | 148 30 05 | Mill Hill | 11024.9 | 4.042373 |
| 34 01 25 | 213 57 03 | Scargo. | 16233.9 | 4.210423 |
| 24 03 21 | 204 01 20 | Mill Hill | 10286.1 | 4.012249 |
| 54 48 55 | 234 39 46 | Scargo. | 23309.4 | 4.367531 |
| 55 43 46 | 235 35 49 | Scargo | 20007.6 | 4.301194 |
| 146 05 15 | 326 01 47 | Griffin's Island. | 12870.9 | 4.109610 |
| 146 49 16 | 326 46 52 | Indian Brook | 9130.2 | 3.96048 |
| 72 03 28 | 252 01 15 | Mill Hill. | 4858.7 | 3.68652 |

**CAPE COD BAY AND PENINSULA**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Station south of Nauset lights. | 41 51 10.90 | 336.3 | 69 57 00.54 | 12.5 |
| Eastham. | 41 49 26.09 | 804.9 | 70 00 14.92 | 344.3 |
| Orleans. | 41 47 32.47 | 1002.2 | 70 00 51.46 | 1188.2 |
| Brewster. | 41 46 12.76 | 393.7 | 70 04 46.46 | 1073.1 |
| Pleasant Bay. | 41 44 34.89 | 1076.4 | 69 58 39.64 | 916.0 |
| Nauset Beach. | 41 44 05.66 | 174.6 | 69 55 34.32 | 793.1 |
| Brewster Unitarian spire, 1846–'68. | 41 45 43.24 | 1334.0 | 70 04 57.32 | 1324.1 |
| Orleans Orthodox spire. | 41 47 04.86 | 149.9 | 69 58 30.20 | 697.4 |
| North Dennis. | 41 44 42.24 | 1303.2 | 70 12 29.82 | 689.0 |
| North Dennis, white spire, 1846–'68. | 41 44 13.77 | 424.8 | 70 11 35.41 | 818.3 |
| North Dennis, gray spire, 1846. | 41 44 14.85 | 458.2 | 70 11 32.53 | 751.7 |
| North Dennis 2. 1868. | 41 43 29.20 | 900.9 | 70 12 04.70 | 108.6 |
| Bass Hole. | 41 42 49.98 | 1542.0 | 70 14 15.54 | 358.4 |
| Monomoy light-house (C. & G. S. & B.). 1835–'46. | 41 33 35.02 | 1080.4 | 69 59 40.76 | 944.5 |
| Monomoy light-house, 1867–'80. | 41 33 33.78 | 1042.1 | 69 59 39.02 | 904.2 |
| Point Gammon light-house (C. & G. S. & B.). 1835–'47. | 41 36 35.00 | 1079.8 | 70 16 00.19 | 4.4 |
| East Scargo (Borden). | 41 44 00.87 | 26.8 | 70 10 16.39 | 378.8 |
| German Hill (Borden). | 41 41 27.90 | 860.7 | 70 12 36.07 | 834.1 |
| Barnstable. | 41 41 48.82 | 1506.2 | 70 18 25.58 | 591.5 |
| Barnstable, Unitarian spire. | 41 42 02.46 | 75.9 | 70 17 57.67 | 1333.4 |
| Barnstable light-house, 1846. | 41 43 21.16 | 652.8 | 70 16 53.34 | 1232.9 |
| Barnstable, west spire. | 41 41 54.89 | 1693.4 | 70 23 03.28 | 75.8 |
| Barnstable court-house (Borden), 1835. | 41 42 06.02 | 185.7 | 70 18 17.64 | 407.8 |

**CAPE COD BAY AND PENINSULA**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 357 25 22 | 177 25 31 | Nauset Harbor | 7047. 4 | 3. 84803 |
| 26 45 49 | 206 43 45 | Mill Hill. | 9561. 2 | 3. 98051 |
| 358 00 57 | 178 01 02 | Mill Hill | 5308. 0 | 3. 724927 |
| 57 29 10 | 237 22 07 | Scargo. | 17399. 0 | 4. 240525 |
| 67 04 26 | 246 57 47 | Scargo | 15012. 7 | 4. 176459 |
| 178 37 43 | 358 37 34 | Blackfish Creek. | 12850. 3 | 4. 108912 |
| 226 24 12 | 46 27 13 | Eastham | 8653. 6 | 3. 93719 |
| 264 08 22 | 84 11 28 | Mill Hill. | 6488. 7 | 3. 81216 |
| 151 16 22 | 331 15 24 | Mill Hill | 4195. 9 | 3. 62282 |
| 206 42 18 | 26 43 33 | Nauset Harbor. | 5796. 6 | 3. 76317 |
| 101 54 35 | 281 52 32 | Pleasant Bay | 4376. 6 | 3. 64114 |
| 126 03 10 | 306 00 08 | Mill Hill. | 7788. 6 | 3. 89146 |
| 223 27 28 | 43 30 36 | Eastham | 9475. 7 | 3. 97661 |
| 256 47 43 | 76 50 56 | Mill Hill. | 6887. 7 | 3. 83808 |
| 150 59 17 | 330 58 07 | Eastham | 4982. 9 | 3. 69749 |
| 67 01 50 | 247 00 46 | Mill Hill. | 2427. 4 | 3. 38514 |
| 1 21 45 | 181 21 41 | German Hill | 5995. 4 | 3. 77782 |
| 284 46 13 | 104 47 20 | Scargo. | 2389. 5 | 3. 37831 |
| 124 56 48 | 304 56 12 | North Dennis | 1533. 5 | 3. 18569 |
| 255 41 00 | 75 41 30 | Scargo. | 1087. 2 | 3. 03631 |
| 122 33 44 | 302 33 06 | North Dennis | 1570. 2 | 3. 19596 |
| 256 34 52 | 76 35 20 | Scargo. | 1014. 8 | 3. 00637 |
| 206 11 59 | 26 12 19 | North Dennis wh. sp | 1532. 4 | 3. 18536 |
| 226 27 41 | 46 28 31 | Scargo. | 2387. 0 | 3. 37786 |
| 317 41 47 | 137 42 53 | German Hill | 3421. 0 | 3. 53415 |
| 239 00 37 | 59 02 54 | Scargo. | 5545. 5 | 3. 74394 |
| 129 11 02 | 309 02 28 | German Hill | 23128. 5 | 4. 364148 |
| 184 31 43 | 4 32 18 | Chatham. | 15340. 9 | 4. 185851 |
| 115 33 14 | 295 19 10 | Shootflying | 32576. 3 | 4. 512902 |
| 184 22 12 | 4 22 46 | Chatham. | 15375. 5 | 4. 186830 |
| 207 35 10 | 27 37 26 | German Hil | 10198. 8 | 4. 008550 |
| 141 27 13 | 321 24 01 | Shootflying. | 10746. 7 | 4. 031276 |
| 90 06 05 | 269 53 29 | Bourne's Hill | 26235. 9 | 4. 418896 |
| 121 49 17 | 301 32 29 | Manomet. | 40993. 4 | 4. 612714 |
| 101 40 35 | 281 29 34 | Bourne's Hill | 23494. 7 | 4. 370970 |
| 129 46 43 | 309 31 28 | Manomet. | 41134. 9 | 4. 614210 |
| 0 11 54 | 180 11 53 | Hyannis | 7264. 8 | 3. 86123 |
| 274 31 03 | 94 34 56 | German Hill. | 8109. 9 | 3. 90902 |
| 278 06 44 | 98 10 18 | German Hill | 7514. 7 | 3. 87591 |
| 236 55 34 | 56 59 12 | North Dennis. | 9040. 3 | 3. 95618 |
| 300 23 10 | 120 26 01 | German Hill | 6899. 2 | 3. 83880 |
| 257 16 32 | 77 20 34 | Scargo. | 8611. 7 | 3. 93509 |
| 84 37 59 | 264 37 12 | Hamblin's Hill | 1634. 2 | 3. 21331 |
| 160 51 43 | 340 51 18 | Scorton Hill. | 2689. 9 | 3. 42974 |
| 278 26 16 | 98 30 03 | German Hill (Borden) | 7985. 4 | 3. 902294 |
| 136 36 20 | 316 24 53 | Manomet. | 34559. 6 | 4. 538569 |

**CAPE COD BAY AND PENINSULA**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Barn cupola. | 41 42 15.22 | 469.6 | 70 19 03.24 | 74.9 |
| Yarmouth Port spire. | 41 42 24.82 | 765.7 | 70 14 37.13 | 858.4 |
| Sursuit Creek. | 41 45 32.41 | 999.7 | 70 08 37.40 | 864.0 |
| Morris Island. | 41 39 29.48 | 909.5 | 69 57 34.14 | 789.9 |
| Harwich Port. | 41 39 51.30 | 1582.6 | 70 04 06.57 | 152.0 |
| West Chatham. | 41 40 09.42 | 290.6 | 70 01 42.19 | 976.0 |
| South Dennis. | 41 39 06.59 | 203.3 | 70 08 12.40 | 286.9 |
| South Dennis, north spire. | 41 40 34.25 | 1056.6 | 70 09 24.49 | 566.5 |
| South Dennis, south spire. | 41 40 21.64 | 667.6 | 70 09 23.64 | 546.8 |
| Herring River spire. | 41 40 13.01 | 401.4 | 70 07 02.58 | 59.7 |
| Point Gammon 2. 1875. | 41 37 04.96 | 153.0 | 70 15 39.32 | 910.3 |
| Mannersen. | 41 41 31.14 | 960.7 | 70 12 16.86 | 389.9 |
| Bass River. | 41 38 38.44 | 1185.9 | 70 12 12.13 | 280.7 |
| Bass River light-house, 1875. | 41 39 06.44 | 198.7 | 70 10 10.84 | 250.8 |
| West Yarmouth spire. | 41 38 59.08 | 1822.7 | 70 13 46.73 | 1081.3 |
| Fish-house, north gable. | 41 38 19.40 | 598.5 | 70 10 38.15 | 833.0 |
| Harwich belfry (C. & G. S. & B.). 1835–'46. | 41 41 12.39 | 382.3 | 70 04 35.97 | 831.8 |
| Marsh. | 41 43 51.92 | 1601.7 | 69 55 39.95 | 923.3 |
| Eldridge. | 41 44 34.88 | 1076.0 | 69 58 39.69 | 917.1 |
| Pochet. | 41 46 39.98 | 1233.3 | 69 56 26.09 | 602.5 |
| Sampson. | 41 45 21.74 | 670.7 | 69 57 00.43 | 9.9 |
| Old Harbor. | 41 42 19.94 | 615.1 | 69 56 01.11 | 25.7 |
| Camp. | 41 43 59.58 | 1838.0 | 69 59 33.25 | 768.4 |

**CAPE COD BAY AND PENINSULA**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 83 49 25 | 263 45 58 | Hamblin's Hill | 7219.9 | 3.85853 |
| 49 37 32 | 229 36 21 | Shootflying. | 3232.7 | 3.50957 |
| 302 02 40 | 122 04 01 | German Hill | 3305.2 | 3.51919 |
| 235 20 18 | 55 22 49 | Scargo. | 6386.0 | 3.80523 |
| 73 56 30 | 253 53 55 | North Dennis | 5588.8 | 3.74732 |
| 54 49 36 | 234 48 08 | Scargo. | 3744.2 | 3.57336 |
| 16 06 39 | 196 05 40 | Monomoy | 7446.3 | 3.87194 |
| 158 29 38 | 338 28 49 | Chatham. | 4683.6 | 3.67058 |
| 318 05 16 | 138 08 37 | Monomoy | 10512.6 | 4.021710 |
| 72 18 56 | 252 11 16 | Point Gammon. | 16833.7 | 4.226180 |
| 232 07 35 | 52 09 31 | Chatham | 5091.7 | 3.70686 |
| 336 18 53 | 156 20 39 | Monomoy. | 9156.7 | 3.96174 |
| 296 50 45 | 116 56 50 | Monomoy | 14251.9 | 4.153874 |
| 70 06 06 | 250 01 10 | Point Gammon. | 11003.9 | 4.041547 |
| 53 22 17 | 233 18 08 | Point Gammon | 10813.4 | 4.033962 |
| 93 44 52 | 273 37 16 | Shootflying. | 15882.2 | 4.200912 |
| 55 07 21 | 235 03 11 | Point Gammon | 10602.1 | 4.025392 |
| 95 08 22 | 275 00 46 | Shootflying. | 15932.0 | 4.202270 |
| 64 10 07 | 244 04 23 | Point Gammon | 13291.6 | 4.123578 |
| 95 04 58 | 274 55 47 | Shootflying. | 19205.7 | 4.283430 |
| 111 05 16 | 291 03 25 | Hyannis | 4151.6 | 3.618211 |
| 136 10 50 | 316 07 23 | Shootflying. | 10368.8 | 4.015727 |
| 29 43 22 | 209 41 07 | Point Gammon 2 | 9454.6 | 3.975644 |
| 51 53 24 | 231 49 18 | Hyannis. | 10879.4 | 4.036604 |
| 173 58 38 | 353 58 22 | German Hill | 5259.1 | 3.72091 |
| 59 00 07 | 238 57 50 | Point Gammon. | 5595.9 | 3.74788 |
| 63 47 16 | 243 43 38 | Point Gammon 2 | 8476.6 | 3.92822 |
| 146 51 58 | 326 50 34 | Mannersen. | 5331.5 | 3.72685 |
| 112 03 12 | 291 58 31 | Shootflying | 10555.6 | 4.023482 |
| 72 38 29 | 252 35 23 | Hyannis. | 6788.8 | 3.831790 |
| 109 06 46 | 285 05 44 | Bass River | 2253.2 | 3.35280 |
| 246 38 09 | 66 39 46 | South Dennis. | 3674.1 | 3.56515 |
| 63 37 12 | 243 29 50 | Point Gammon | 17143.5 | 4.234100 |
| 72 21 27 | 252 12 15 | Hyannis. | 20176.7 | 4.304850 |
| 49 22 13 | 229 20 08 | Chatham | 5741.0 | 3.75899 |
| 129 04 40 | 309 01 42 | Mill Hill. | 7943.8 | 3.90003 |
| 287 40 46 | 107 42 46 | Marsh | 4359.9 | 3.63948 |
| 2 16 20 | 182 16 14 | Chatham. | 5069.0 | 3.70492 |
| 348 22 43 | 168 23 14 | Marsh | 5293.3 | 3.72373 |
| 38 39 36 | 218 38 07 | Eldridge. | 4941.7 | 3.69388 |
| 326 07 40 | 146 08 34 | Marsh | 3337.3 | 3.52340 |
| 57 46 43 | 237 45 37 | Eldridge. | 2711.0 | 3.43313 |
| 76 53 24 | 256 51 33 | Chatham | 3971.3 | 3.59893 |
| 138 39 13 | 318 37 28 | Eldridge. | 5546.8 | 3.74404 |
| 272 29 21 | 92 51 56 | Marsh | 5396.8 | 3.73214 |
| 345 22 32 | 165 23 02 | Chatham. | 4109.0 | 3.61374 |

**CAPE COD BAY AND PENINSULA**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Basin. | 41 39 48.50 | 1496.2 | 69 56 41.66 | 963.8 |
| Shells. | 41 37 52.80 | 1628.8 | 69 57 41.45 | 959.4 |
| Pine. | 41 40 08.56 | 264.1 | 69 59 35.48 | 820.8 |
| Mosquito. | 41 39 26.91 | 830.1 | 69 57 32.60 | 754.3 |
| Cove. | 41 36 56.18 | 1733.1 | 69 58 35.17 | 814.3 |
| Strong. | 41 43 12.48 | 385.0 | 69 57 29.61 | 684.5 |
| Crow's Lookout. | 41 43 06.96 | 214.7 | 69 58 25.46 | 588.5 |
| Sipson's Island. | 41 44 09.28 | 286.0 | 69 57 52.03 | 1202.4 |
| Namequoit. | 41 45 26.54 | 818.8 | 69 57 42.48 | 981.3 |
| Mayo. | 41 46 00.17 | 5.2 | 69 57 10.44 | 241.1 |
| Cumming's (D.) flagstaff, 1868. | 41 47 12.17 | 375.5 | 69 57 04.36 | 100.7 |
| Mayo's south chimney. | 41 47 20.68 | 638.0 | 69 56 45.80 | 1057.5 |
| Hopkins. | 41 46 02.05 | 63.2 | 70 02 51.54 | 1190.5 |
| Sears. | 41 44 38.30 | 1181.6 | 70 07 57.09 | 1319.1 |
| Morris Island 2. 1880. | 41 39 29.25 | 902.4 | 69 57 34.17 | 790.6 |
| Chatham spire. | 41 41 02.79 | 86.1 | 69 57 39.96 | 924.2 |
| Chatham Congregational belfry, 1846. | 41 41 15.97 | 492.7 | 69 58 18.40 | 425.5 |
| Chatham Congregational spire, 1868–1880. | 41 40 58.54 | 1805.9 | 69 57 41.72 | 964.9 |
| Chatham flagstaff, 1868. | 41 40 43.77 | 1350.3 | 69 57 23.51 | 543.8 |
| Chatham, south light-house, 1846. | 41 40 17.00 | 524.5 | 69 56 58.48 | 1352.8 |
| Chatham, south light-house, 1880. | 41 40 17.30 | 533.8 | 69 57 01.50 | 34.7 |
| Chatham, north light-house, 1880. | 41 40 18.28 | 564.0 | 69 57 01.27 | 29.4 |
| Stage Harbor (or Harding's Beach) light-house, 1880. | 41 39 31.55 | 973.4 | 69 59 03.16 | 73.1 |

**CAPE COD BAY AND PENINSULA**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 142 09 09 | 322 07 45 | Chatham | 4775.5 | 3.67902 |
| 191 20 43 | 11 21 10 | Old Harbor. | 4765.4 | 3.67810 |
| 168 05 40 | 348 04 55 | Chatham | 7501.4 | 3.87514 |
| 195 43 12 | 15 44 19 | Old Harbor. | 8562.5 | 3.93260 |
| 199 03 58 | 19 04 29 | Chatham | 3334.3 | 3.52301 |
| 278 44 09 | 98 46 05 | Basin. | 4068.6 | 3.60945 |
| 114 19 58 | 294 18 36 | Pine | 3119.8 | 3.49412 |
| 158 26 56 | 338 26 06 | Chatham. | 4769.9 | 3.67851 |
| 166 46 22 | 346 45 42 | Pine | 6097.3 | 3.78514 |
| 206 17 09 | 26 18 24 | Basin. | 5930.1 | 3.77306 |
| 244 20 43 | 64 21 56 | Marsh | 2811.6 | 3.44895 |
| 308 23 02 | 128 24 01 | Old Harbor. | 2610.3 | 3.41669 |
| 250 03 14 | 70 05 04 | Marsh | 4069.3 | 3.60952 |
| 293 28 57 | 113 30 33 | Old Harbor. | 3638.7 | 3.56095 |
| 208 04 01 | 28 04 35 | Sampson | 2533.6 | 3.40373 |
| 279 56 25 | 99 57 53 | Marsh. | 3099.1 | 3.49124 |
| 217 54 10 | 37 55 01 | Pochet | 2871.6 | 3.45813 |
| 315 52 01 | 135 53 22 | Marsh. | 4066.6 | 3.60923 |
| 38 05 32 | 218 04 33 | Eldridge | 3343.0 | 3.52414 |
| 104 26 06 | 284 24 08 | Mill Hill. | 4209.9 | 3.62427 |
| 318 19 54 | 138 20 20 | Pochet | 1329.4 | 3.12367 |
| 358 28 32 | 178 28 35 | Sampson. | 3408.0 | 3.53250 |
| 340 04 17 | 160 04 30 | Pochet | 1335.8 | 3.12574 |
| 5 15 47 | 185 15 37 | Sampson. | 3685.0 | 3.56644 |
| 224 44 29 | 44 45 49 | Orleans 2 | 3933.3 | 3.59476 |
| 255 23 01 | 75 24 51 | Mill Hill. | 3928.0 | 3.59417 |
| 236 29 35 | 56 31 42 | Rock Point | 5292.0 | 3.723618 |
| 251 44 27 | 71 49 40 | Mill Hill. | 11431.1 | 4.058202 |
| 113 22 58 | 293 21 37 | Pine | 3057.5 | 3.48536 |
| 158 32 16 | 338 31 27 | Chatham. | 4689.5 | 3.67113 |
| 133 04 16 | 313 03 30 | Chatham | 2165.1 | 3.33549 |
| 73 38 48 | 253 36 07 | West Chatham. | 5840.2 | 3.76643 |
| 147 06 53 | 327 06 33 | Chatham | 1276.1 | 3.10589 |
| 66 28 52 | 246 26 36 | West Chatham. | 5141.8 | 3.71111 |
| 59 38 29 | 239 37 13 | Pine | 3049.9 | 3.48429 |
| 136 14 23 | 316 13 39 | Chatham. | 2228.5 | 3.34802 |
| 136 27 51 | 316 26 55 | Chatham | 2849.0 | 3.45470 |
| 212 42 05 | 32 43 00 | Old Harbor. | 3526.1 | 3.54730 |
| 29 22 06 | 209 21 42 | Morris Island | 1682.2 | 3.22588 |
| 138 41 16 | 318 40 03 | Chatham. | 3849.1 | 3.58536 |
| 85 40 57 | 265 39 15 | Pine | 3572.2 | 3.55293 |
| 139 23 10 | 319 22 02 | Chatham. | 3796.5 | 3.57938 |
| 85 12 34 | 265 10 51 | Pine | 3580.0 | 3.55388 |
| 139 01 37 | 319 00 26 | Chatham. | 3777.3 | 3.57718 |
| 184 33 14 | 4 33 24 | Chatham | 4306.6 | 3.63414 |
| 271 58 06 | 91 59 05 | Morris Island 2. | 2060.2 | 3.31391 |

**CAPE COD BAY AND PENINSULA**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Hyannis, west spire. | 41 39 05.77 | 178.0 | 70 17 15.21 | 351.9 |
| Hyannis, Universalist spire. | 41 39 14.38 | 443.6 | 70 16 56.08 | 1297.7 |
| Hyannis light-house, 1875. | 41 38 10.79 | 332.9 | 70 17 20.20 | 467.5 |
| Bishop and Clerks. | 41 34 27.44 | 846.5 | 70 15 01.96 | 45.4 |
| Bishop and Clerks light-house, 1875. | 41 34 27.52 | 849.0 | 70 15 02.04 | 47.3 |
| Breakwater, east end, spindle. | 41 37 27.31 | 842.5 | 70 17 34.06 | 788.5 |
| Great Rock, spindle. | 41 37 03.52 | 108.6 | 70 17 10.38 | 240.3 |
| Marvin's Cottage, cupola. | 41 38 04.00 | 123.4 | 70 18 12.06 | 279.1 |
| Marston's Mill. | 41 38 49.68 | 1532.7 | 70 24 56.98 | 1318.6 |
| Osterville. | 41 37 52.16 | 1609.2 | 70 22 57.14 | 1322.6 |
| Osterville, spire. | 41 37 42.08 | 1298.2 | 70 23 09.29 | 215.0 |
| Osterville Point. | 41 37 02.13 | 65.7 | 70 22 10.70 | 247.7 |
| Collier's Ledge. | 41 35 48.36 | 1492.0 | 70 21 06.69 | 154.9 |
| Centerville, church. | 41 38 44.94 | 1386.4 | 70 20 49.27 | 1140.2 |
| Indian Hill. | 41 52 48.13 | 1793.4 | 70 32 01.75 | 40.4 |
| East Plymouth. | 41 52 58.09 | 1792.2 | 70 32 01.74 | 40.1 |
| Plymouth Cliff. | 41 49 40.62 | 1253.2 | 70 32 37.24 | 859.4 |
| Sandwich Orthodox spire. | 41 45 28.35 | 874.6 | 70 30 00.45 | 10.4 |
| Spring Hill Academy. | 41 44 58.86 | 1815.9 | 70 27 36.58 | 845.2 |

**NANTUCKET AND VICINITY.**

| | | | | |
|---|---|---|---|---|
| Tuckanuck Telegraph. | 41 18 14.507 | 447.5 | 70 15 08.473 | 197.1 |
| Clark's Cove. | 41 15 20.474 | 631.7 | 70 10 43.165 | 1004.9 |

**CAPE COD BAY AND PENINSULA**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 36 30 26 | 216 29 38 | Hyannis | 2779.8 | 3.44402 |
| 127 05 57 | 307 03 34 | Shootflying. | 6220.4 | 3.79382 |
| 39 59 35 | 219 58 35 | Hyannis | 3262.7 | 3.51358 |
| 336 00 24 | 156 01 15 | Point Gammon 2. | 4370.0 | 3.64048 |
| 311 00 21 | 131 01 28 | Point Gammon 2 | 3094.9 | 3.49064 |
| 70 43 07 | 250 42 23 | Hyannis | 1629.9 | 3.21216 |
| 146 54 23 | 326 50 32 | Shootflying | 14731.2 | 4.168237 |
| 194 35 06 | 14 36 43 | German Hill. | 13406.6 | 4.127318 |
| 143 17 05 | 323 14 49 | Hyannis | 7923.2 | 3.898898 |
| 196 17 28 | 16 19 18 | Mannersen. | 13617.3 | 4.134090 |
| 123 24 36 | 303 24 01 | Hyannis | 1458.8 | 3.16401 |
| 284 32 29 | 104 33 45 | Point Gammon 2. | 2744.2 | 3.43842 |
| 146 00 32 | 325 58 06 | Shootflying | 9074.4 | 3.95782 |
| 268 47 12 | 88 48 12 | Point Gammon 2. | 2108.8 | 3.32403 |
| 232 05 49 | 52 09 45 | Mannersen | 10410.6 | 4.017478 |
| 297 14 29 | 117 16 10 | Point Gammon 2. | 3977.4 | 3.599598 |
| 190 12 51 | 10 13 20 | Hamblin's Hill | 5650.6 | 3.75209 |
| 233 23 02 | 53 25 46 | Shootflying. | 7124.1 | 3.85273 |
| 278 08 03 | 98 12 53 | Point Gammon | 10239.3 | 4.010269 |
| 166 26 30 | 346 25 39 | Hamblin's Hill. | 7546.2 | 3.877728 |
| 266 56 07 | 86 59 14 | Hyannis | 6551.1 | 3.81632 |
| 207 00 14 | 27 01 47 | Shootflying. | 7108.0 | 3.85175 |
| 253 02 21 | 73 04 50 | Hyannis | 5421.5 | 3.73412 |
| 193 54 09 | 13 55 03 | Shootflying. | 7793.3 | 3.89172 |
| 182 16 53 | 2 17 04 | Shootflying | 9848.5 | 3.99337 |
| 252 39 14 | 72 42 51 | Point Gammon. | 7940.2 | 3.89983 |
| 295 44 23 | 115 45 58 | Hyannis | 3664.4 | 3.56400 |
| 179 51 28 | 359 51 28 | Shootflying. | 4392.9 | 3.64275 |
| 3 44 24 | 183 44 08 | Peaked Cliff | 8247.3 | 3.91631 |
| 136 11 00 | 316 08 42 | Manomet. | 6867.9 | 3.83683 |
| 298 19 57 | 118 34 05 | Scargo | 33391.9 | 4.523641 |
| 324 39 06 | 144 46 34 | Shootflying. | 26864.0 | 4.429170 |
| 287 53 18 | 108 07 49 | Scargo | 31746.8 | 4.501700 |
| 314 01 42 | 134 09 33 | Shootflying. | 22758.0 | 4.357135 |
| 149 24 54 | 329 23 18 | Peaked Cliff | 6560.3 | 3.81692 |
| 286 06 57 | 106 10 30 | Scorton Neck. | 7679.6 | 3.88534 |
| 100 17 06 | 280 14 57 | Mount Schaum | 4540.9 | 3.65714 |
| 134 34 11 | 314 30 59 | Peaked Cliff. | 9347.6 | 3.97070 |

**NANTUCKET AND VICINITY.**

| | | | | |
|---|---|---|---|---|
| 275 52 33.5 | 95 58 00.0 | Nantucket Cliff | 11570.8 | 4.063364 |
| 172 48 38.0 | 352 46 26.8 | Hyannis. | 36657.0 | 4.564157 |
| 231 57 02.5 | 51 59 33.8 | Nantucket Cliff | 6777.2 | 3.831053 |
| 131 01 56.7 | 310 59 01.6 | Tuckanuck Telegraph. | 8182.1 | 3.912864 |

**NANTUCKET AND VICINITY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Windmill Range. | 41 16 40.219 | 1240.8 | 70 06 49.575 | 1153.7 |
| Weeweeder Pond. | 41 14 35.284 | 1088.4 | 70 05 37.923 | 883.1 |
| Gibbs' Pond. | 41 16 53.650 | 1655.1 | 70 01 31.457 | 732.0 |
| Squam Head. | 41 19 33.485 | 1032.9 | 69 59 56.052 | 1303.5 |
| Nantucket south-towered Unitarian church, 1835–1875 (C. & G. S. & B.). | 41 16 56.717 | 1749.7 | 70 05 58.086 | 1351.5 |
| North Pond. | 41 17 38.41 | 1184.9 | 70 10 32.15 | 748.1 |
| Sankaty Head. | 41 16 59.91 | 1848.1 | 69 57 53.41 | 1242.9 |
| Sankaty Head light-house, 1867. | 41 17 01.21 | 37.3 | 69 57 56.52 | 1315.2 |
| Forked Pond. | 41 14 15.94 | 491.7 | 70 01 03.65 | 85.0 |
| Further Creek. | 41 16 39.72 | 1225.2 | 70 14 06.85 | 159.4 |
| Muskeget Island. | 41 20 14.11 | 435.2 | 70 17 58.47 | 1359.5 |
| Mitchell's house (astronomical station, 1845–1849). | 41 16 59.45 | 1833.9 | 70 06 00.50 | 11.6 |
| Shawaukemo. | 41 17 01.80 | 55.5 | 70 03 04.82 | 112.2 |
| Bluff. | 41 17 31.40 | 968.5 | 70 06 26.77 | 622.9 |
| Coatue Point 2. 1875. | 41 18 05.39 | 166.3 | 70 04 39.87 | 927.6 |
| Coatue Point. | 41 19 06.62 | 204.3 | 70 02 57.07 | 1327.3 |
| Folger. | 41 17 17.01 | 524.7 | 70 06 16.56 | 385.3 |
| Folger (astronomical latitude station, 1866). | 41 17 16.94 | 522.6 | 70 06 16.56 | 385.3 |
| High School cupola. | 41 17 05.98 | 184.4 | 70 06 12.76 | 296.9 |
| Nantucket Baptist church. | 41 16 52.66 | 1624.4 | 70 06 07.00 | 162.9 |
| Nantucket north-towered church. | 41 17 09.94 | 306.6 | 70 06 08.22 | 191.2 |
| Brant Point light-house, 1867–1875. | 41 17 23.20 | 715.7 | 70 05 34.61 | 805.3 |
| Nantucket Range Beacon, 1875 (discontinued Aug. 1, 1880). | 41 16 23.92 | 737.9 | 70 04 42.86 | 997.6 |

**NANTUCKET AND VICINITY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 65 40 37.8 | 245 38 03.7 | Clark's Cove | 5967.9 | 3.775823 |
| 176 43 31.0 | 356 43 28.2 | Nantucket Cliff. | 1717.8 | 3.234985 |
| 156 36 16.3 | 336 35 29.1 | Windmill Range. | 4199.6 | 3.623209 |
| 101 07 33.2 | 281 04 12.0 | Clark's Cove. | 7242.4 | 3.859885 |
| 171 49 01.3 | 351 48 12.0 | Nantucket light-house | 12177.0 | 4.085540 |
| 86 49 33.5 | 266 46 03.6 | Windmill Range. | 7415.0 | 3.870110 |
| 69 33 15.4 | 249 28 39.7 | Nantucket Cliff | 10373.3 | 4.015918 |
| 24 14 32.5 | 204 13 29.5 | Gibbs' Pond. | 5407.3 | 3.732982 |
| 132 56 28.1 | 312 55 51.3 | Nantucket Cliff | 1770.6 | 3.248117 |
| 200 27 28.0 | 20 29 34.8 | Nantucket light-house. | 12764.6 | 4.106008 |
| 270 53 05 | 90 55 29 | Nantucket Cliff | 5081.4 | 3.70598 |
| 3 26 50 | 183 26 43 | Clark's Cove. | 4263.0 | 3.62972 |
| 148 57 26 | 328 56 05 | Squam Head | 5530.2 | 3.74274 |
| 95 04 58 | 274 59 02 | Nantucket Cliff. | 12622.9 | 4.10116 |
| 150 21 43 | 330 18 32 | Nantucket light-house | 13602.2 | 4.13361 |
| 94 55 35 | 274 49 51 | Nantucket Cliff. | 12547.3 | 4.09855 |
| 118 57 34 | 298 53 46 | Windmill Range | 9201.1 | 3.96384 |
| 95 21 42 | 275 18 41 | Weeweeder Pond. | 6414.6 | 3.80717 |
| 297 15 37 | 117 17 51 | Clark's Cove | 5334.4 | 3.72709 |
| 250 03 39 | 70 06 01 | North Pond. | 5314.0 | 3.72542 |
| 287 28 07 | 107 35 27 | Nantucket Cliff | 16213.6 | 4.20988 |
| 294 47 16 | 114 52 11 | North Pond. | 11439.0 | 4.05838 |
| 132 08 17 | 312 07 42 | Nantucket Cliff | 1671.9 | 3.22322 |
| 62 32 40 | 242 32 08 | Windmill Range. | 1286.9 | 3.10953 |
| 101 09 36 | 281 07 05 | Nantucket Cliff | 5430.3 | 3.73482 |
| 182 06 55 | 2 07 07 | Nantucket light-house. | 11809.2 | 4.07222 |
| 205 12 51 | 25 15 17 | Nantucket light-house | 12036.8 | 4.08051 |
| 280 58 31 | 101 00 44 | Shawaukemo. | 4787.2 | 3.68008 |
| 311 33 44 | 131 34 47 | Shawaukemo | 2956.2 | 3.47074 |
| 67 09 07 | 247 07 56 | Bluff. | 2699.4 | 3.43127 |
| 298 55 46 | 118 59 07 | Sankaty Head | 8073.6 | 3.90707 |
| 334 05 39 | 154 06 36 | Gibbs' Pond. | 4560.2 | 3.65898 |
| 123 48 13 | 303 47 48 | Nantucket Cliff | 1042.4 | 3.01802 |
| 325 31 22 | 145 31 34 | South-towered church. | 759.7 | 2.88062 |
| 180 00 | 0 00 | Folger | 2.234 | 0.34911 |
| 165 24 52 | 345 24 49 | Folger | 351.6 | 2.54602 |
| 309 56 45 | 129 56 55 | South-towered church. | 445.4 | 2.64877 |
| 140 43 44 | 320 43 13 | Nantucket Cliff | 1719.8 | 3.23548 |
| 238 54 03 | 58 54 09 | South-towered church. | 242.4 | 2.38460 |
| 329 59 12 | 149 59 19 | South-towered church. | 470.9 | 2.67292 |
| 138 20 34 | 318 20 29 | Folger. | 291.8 | 2.46504 |
| 101 46 38 | 281 46 04 | Bluff | 1240.1 | 3.09345 |
| 224 22 18 | 44 22 54 | Coatue Point 2. | 1821.0 | 3.26030 |
| 130 43 50 | 310 42 41 | Bluff | 3190.8 | 3.50390 |
| 242 52 06 | 62 53 11 | Shawaukemo. | 2563.5 | 3.40884 |

NANTUCKET AND VICINITY—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Nantucket Cliff Range Beacon (front), 1875. | 41 17 37.96 | 1170.9 | 70 06 24.12 | 561.3 |
| Nantucket Cliff Range Beacon (rear), 1875. | 41 17 35.55 | 1096.6 | 70 06 25.10 | 584.0 |
| Nantucket (Borden). | 41 17 39.86 | 1229.6 | 70 06 39.85 | 927.2 |
| Tuckanuck Island, north house (Borden). | 41 18 38.81 | 1197.2 | 70 15 55.41 | 1288.8 |
| Brant Point light-house (Borden), 1835. | 41 17 24.48 | 755.1 | 70 05 35.81 | 833.3 |

MARTHA'S VINEYARD AND VINEYARD SOUND.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| Prospect Chilmark (C. and G. S. and B.). | 41 21 56.838 | 1753.5 | 70 44 51.049 | 1186.3 |
| Davis Hill. | 41 31 24.305 | 749.9 | 70 39 39.245 | 910.0 |
| Desert Hill. | 41 29 28.731 | 886.4 | 70 44 21.354 | 495.3 |
| East Chop 2. 1875. | 41 28 04.635 | 143.0 | 70 33 50.903 | 1181.2 |
| Cape Poge. | 41 25 11.499 | 354.8 | 70 27 03.747 | 87.0 |
| West Chop 2. 1875. | 41 28 52.61 | 1622.9 | 70 35 58.26 | 1351.6 |
| Watcha Pond. | 41 20 52.19 | 1609.9 | 70 36 38.35 | 891.5 |
| Nashaquitsa Cliff. | 41 20 00.34 | 10.5 | 70 44 27.30 | 634.7 |
| Herring Pond. | 41 20 47.35 | 1460.6 | 70 31 34.16 | 794.1 |
| Edgartown. | 41 23 51.77 | 1596.9 | 70 32 55.96 | 1299.9 |
| Edgartown spire. | 41 23 18.64 | 575.0 | 70 30 55.88 | 1298.2 |
| Edgartown light-house, 1875. | 41 23 27.29 | 841.9 | 70 30 12.76 | 296.4 |
| Molasha Hill. | 41 20 29.02 | 895.2 | 70 48 38.50 | 895.1 |
| Gay Head. | 41 20 50.30 | 1243.2 | 70 50 13.96 | 324.5 |
| Gay Head light-house (Borden), 1835. | 41 20 54.54 | 1682.4 | 70 50 09.36 | 217.6 |
| Gay Head light-house, 1843–45. | 41 20 54.10 | 1668.9 | 70 50 08.54 | 198.6 |

**NANTUCKET AND VICINITY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 250 45 18 | 70 46 27 | Coatue Point 2 | 2568. 9 | 3. 40974 |
| 283 30 14 | 103 32 26 | Shawaukemo. | 4769. 8 | 3. 67850 |
| 249 23 03 | 69 24 13 | Coatue Point 2 | 2615. 6 | 3. 41757 |
| 16 59 59 | 196 59 58 | Bluff. | 133. 9 | 2. 12675 |
| 207 04 02 | 27 06 37 | Nantucket light-house | 11936. 3 | 4. 07687 |
| 323 51 45 | 143 52 13 | South-towered church. | 1647. 9 | 3. 21693 |
| 277 57 28 | 98 03 35 | Nantucket | 13052. 0 | 4. 11568 |
| 282 42 49 | 102 49 23 | South-towered church. | 14249. 8 | 4. 15381 |
| 107 40 01 | 287 39 19 | Nantucket | 1563. 8 | 3. 19417 |
| 31 11 25 | 211 11 10 | South-towered church. | 1001. 2 | 3. 00051 |

**MARTHA'S VINEYARD AND VINEYARD SOUND.**

| | | | | |
|---|---|---|---|---|
| 219 19 40. 2 | 39 22 25. 8 | Indian | 9172. 2 | 3. 962471 |
| 266 18 36. 5 | 86 29 03. 5 | Sampson. | 22088. 2 | 4. 344161 |
| 302 56 44. 7 | 123 05 03. 7 | Cape Poge light-house | 20852. 1 | 4. 319151 |
| 7 48 07. 7 | 187 47 27. 0 | Indian. | 10511. 0 | 4. 021646 |
| -2 50 03. 3 | 182 49 43. 7 | Prospect Chilmark | 13958. 0 | 4. 144824 |
| 323 11 30. 1 | 143 13 56. 2 | Indian. | 8551. 3 | 3. 932032 |
| 127 21 09. 5 | 307 17 18. 7 | Davis' Hill | 10160. 2 | 4. 006904 |
| 65 56 35. 1 | 245 52 03. 8 | Indian. | 10420. 2 | 4. 017875 |
| 119 30 31. 7 | 299 26 02. 2 | East Chop 2 | 10856. 5 | 4. 035691 |
| 93 21 19. 8 | 273 12 19. 3 | Indian. | 19001. 4 | 4. 278786 |
| 132 25 13 | 312 22 47 | Davis' Hill | 6940. 6 | 3. 84140 |
| 296 35 19 | 116 36 43 | East Chop 2. | 3304. 9 | 3. 51916 |
| 99 55 21 | 279 49 55 | Prospect Chilmark | 11624. 9 | 4. 06539 |
| 148 14 21 | 328 11 41 | Indian. | 10690. 1 | 4. 02898 |
| 171 16 11 | 351 15 55. 5 | Prospect Chilmark | 3635. 8 | 3. 56060 |
| 256 52 02 | 77 02 13. 5 | Sampson. | 22067. 3 | 4. 34375 |
| 96 40 26 | 276 31 39 | Prospect Chilmark | 18646. 6 | 4. 27060 |
| 126 04 56 | 305 58 55 | Indian. | 15701. 8 | 4. 19595 |
| 78 01 14 | 257 53 21 | Prospect Chilmark | 16989. 9 | 4. 23019 |
| 108 14 05 | 288 08 58 | Indian. | 11361. 4 | 4. 05543 |
| 82 40 02 | 262 30 50 | Prospect Chilmark | 19570. 4 | 4. 29160 |
| 108 38 42 | 288 32 15 | Indian. | 14331. 0 | 4. 15628 |
| 149 23 47 | 329 21 22 | East Chop 2 | 9942. 8 | 3. 99751 |
| 310 38 40 | 130 39 26 | Sampson. | 2152. 9 | 3. 33303 |
| 242 50 46 | 62 53 16 | Prospect Chilmark | 5941. 0 | 3. 77386 |
| 130 33 23 | 310 28 30 | Cuttyhunk. | 13575. 0 | 4. 13274 |
| 135 14 46 | 315 10 56 | Cuttyhunk | 11500. 6 | 4. 06072 |
| 235 28 19 | 55 34 38 | Indian. | 16156. 6 | 4. 20835 |
| 134 24 32 | 314 20 38 | Cuttyhunk | 11484. 4 | 4. 06011 |
| 235 38 30 | 55 44 46 | Indian. | 15994. 5 | 4. 20397 |
| 134 23 19 | 314 19 25 | Cuttyhunk | 11507. 5 | 4. 06098 |
| 235 33 50 | 55 40 05 | Indian. | 15986. 0 | 4. 20374 |

**MARTHA'S VINEYARD AND VINEYARD SOUND**—Continued.

| Stations. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Gay Head light-house, 1875. | 41 20 54.59 | 1684.0 | 70 50 07.58 | 176.2 |
| East Chop. | 41 28 04.80 | 148.1 | 70 33 50.91 | 1181.3 |
| East Chop Telegraph. | 41 28 04.72 | 145.6 | 70 33 49.00 | 1137.0 |
| East Chop light-house, 1875. | 41 28 13.44 | 414.5 | 70 34 04.96 | 115.1 |
| Tarpaulin Cove light-house, 1835–'45 (C. and G. S. and B.). | 41 28 07.90 | 243.7 | 70 45 28.74 | 666.8 |
| Kotayma House, north tower. | 41 21 30.10 | 928.5 | 70 30 19.67 | 457.2 |
| Observatory with red roof, flag-staff. | 41 26 12.76 | 393.6 | 70 36 18.67 | 433.5 |
| Prospect House, cupola, flag-staff. | 41 26 41.34 | 1275.2 | 70 34 45.39 | 1053.6 |
| Union Chapel. | 41 27 16.82 | 518.9 | 70 33 31.05 | 720.6 |
| Highland House, north tower. | 41 27 50.26 | 1550.4 | 70 33 36.17 | 839.4 |
| Seaview House, north tower. | 41 27 28.54 | 880.4 | 70 33 23.06 | 535.2 |
| No Man's Land (C. & G. S. & B.). | 41 15 11.70 | 360.9 | 70 48 49.20 | 1145.4 |
| Bowman's Point. | 41 32 36.46 | 1124.8 | 70 36 05.84 | 135.4 |
| Bowman's Hill observatory. | 41 32 38.10 | 1175.4 | 70 36 04.32 | 100.1 |
| Nobska Point light-house, 1835–'75 (C. & G. S. & B.). | 41 30 57.24 | 1765.9 | 70 39 20.20 | 468.4 |
| White house, south gable. | 41 32 46.42 | 1432.1 | 70 35 43.10 | 998.9 |
| White house, chimney. | 41 32 09.08 | 280.1 | 70 39 10.00 | 231.8 |
| Menauhant Hotel, west chimney. | 41 33 01.00 | 30.8 | 70 33 09.76 | 226.2 |
| Menauhant Landing, flagstaff. | 41 32 59.68 | 1841.2 | 70 33 08.92 | 206.7 |
| Wood's Holl, Episcopal spire. | 41 31 19.86 | 612.7 | 70 39 48.10 | 1115.3 |
| Davis Neck. | 41 32 54.42 | 1678.9 | 70 33 48.63 | 1127.1 |
| Monaunt Hill. | 41 33 05.51 | 169.9 | 70 32 32.48 | 752.7 |
| Sampson (Borden). | 41 22 41.51 | 1280.5 | 70 29 02.66 | 61.8 |

**MARTHA'S VINEYARD AND VINEYARD SOUND**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 216 50 44 | 36 57 40 | Davis Hill | 24294.1 | 4.38550 |
| 255 20 32 | 75 24 01 | Prospect Chilmark. | 7604.3 | 3.88106 |
| 326 03 48 | 146 06 59 | Sampson | 12005.8 | 4.07939 |
| 65 54 57 | 245 50 26 | Indian. | 10422.0 | 4.01795 |
| 99 28 08 | 279 21 01 | Naushon | 15154.1 | 4.18053 |
| 128 57 22 | 308 53 28 | Wood's Holl. | 10511.6 | 4.02167 |
| 127 14 39 | 307 10 58 | Davis' Hill | 9736.4 | 3.98840 |
| 114 41 44 | 294 40 29 | West Chop 2. | 2893.2 | 3.46138 |
| 303 03 03 | 123 06 14 | Indian | 7979.2 | 3.90196 |
| 355 37 28 | 175 37 53 | Prospect Chilmark. | 11480.7 | 4.05997 |
| 118 48 51 | 298 42 00 | Indian | 16457.4 | 4.21636 |
| 219 01 41 | 39 02 32 | Sampson. | 2848.4 | 3.45460 |
| 82 30 29 | 262 27 36 | Indian | 6136.3 | 3.78791 |
| 278 17 44 | 98 23 51 | Cape Poge. | 13022.7 | 4.11470 |
| 206 11 43 | 26 12 19 | East Chop 2 | 2864.2 | 3.45700 |
| 284 27 19 | 104 32 24 | Cape Poge. | 11070.8 | 4.04418 |
| 162 39 15 | 342 39 02 | East Chop 2 | 1545.3 | 3.18901 |
| 323 39 05 | 143 42 04 | Sampson. | 10529.6 | 4.02241 |
| 326 13 56 | 146 16 57 | Sampson | 11442.7 | 4.05853 |
| 68 53 54 | 248 49 13 | Indian. | 10565.7 | 4.02390 |
| 295 36 42 | 115 40 53 | Cape Poge | 9768.3 | 3.98982 |
| 72 51 45 | 252 46 55 | Indian. | 10633.6 | 4.02668 |
| 151 35 57 | 331 31 11 | Cuttyhunk | 21162.2 | 4.32556 |
| 203 52 57 | 23 55 34 | Prospect Chilmark. | 13671.3 | 4.13581 |
| 331 47 15 | 151 51 55 | Sampson | 20810.4 | 4.31828 |
| 26 47 39 | 206 44 37 | Indian. | 14157.3 | 4.15098 |
| 358 50 38 | 178 50 42 | West Chop 2 | 6957.9 | 3.84248 |
| 65 27 54 | 245 25 31 | Davis' Hill. | 5477.7 | 3.73860 |
| 11 02 33 | 191 01 40 | Indian | 9759.3 | 3.98942 |
| 68 40 29 | 248 37 09 | Desert Hill. | 7499.3 | 3.87502 |
| 343 19 41 | 163 20 55 | East Chop 2 | 9074.0 | 3.95780 |
| 28 05 44 | 208 02 27 | Indian. | 14672.7 | 4.16651 |
| 315 30 25 | 135 33 56 | East Chop 2 | 10566.0 | 4.02391 |
| 10 07 22 | 190 06 22 | Indian. | 11981.5 | 4.07851 |
| 329 35 08 | 149 39 11 | Cape Poge | 16790.0 | 4.22505 |
| 38 01 31 | 217 56 32 | Indian. | 16997.3 | 4.23038 |
| 329 34 26 | 149 38 28 | Cape Poge | 16745.2 | 4.22389 |
| 38 09 42 | 218 04 43 | Indian. | 16977.4 | 4.22987 |
| 305 58 51 | 126 02 48 | East Chop 2 | 10243.1 | 4.01043 |
| 6 46 37 | 186 46 02 | Indian. | 10348.8 | 4.01489 |
| 340 36 44 | 160 39 53 | Sampson | 20031.3 | 4.30171 |
| 35 57 42 | 215 53 09 | Indian. | 16292.6 | 4.21199 |
| 345 46 00 | 165 48 19 | Sampson | 19848.1 | 4.29772 |
| 39 57 48 | 219 52 25 | Indian. | 17649.4 | 4.24673 |
| 86 30 32 | 266 20 05 | Prospect Chilmark | 22082.6 | 4.34405 |
| 109 28 44 | 289 21 03 | Indian. | 17191.4 | 4.23531 |

**MARTHA'S VINEYARD AND VINEYARD SOUND**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Succonnesset. | 41 33 31.43 | 969.6 | 70 28 36.29 | 840.9 |
| Succonnesset (Borden). | 41 33 34.76 | 1072.4 | 70 28 31.66 | 733.6 |
| West Chop. | 41 28 54.29 | 1674.8 | 70 36 18.04 | 418.6 |
| Cape Poge light-house (Borden), 1835. | 41 25 18.54 | 571.9 | 70 27 03.40 | 79.0 |
| Holmes' Hole spire. | 41 27 15.15 | 467.3 | 70 36 20.18 | 468.4 |
| Holmes' Hole wind-mill (Borden). | 41 27 14.81 | 456.8 | 70 36 20.71 | 480.7 |
| Holmes' Hole (West Chop) light-house, 1835–'45 (C. & G. S. & B.). | 41 28 57.66 | 1778.7 | 70 36 10.78 | 250.1 |
| Holmes' Hole (West Chop) light-house, 1875. | 41 28 51.06 | 1575.1 | 70 36 00.96 | 22.3 |
| Cotuit Neck. | 41 35 31.16 | 961.3 | 70 26 44.25 | 1024.9 |

**BUZZARD'S BAY.**

| | | | | |
|---|---|---|---|---|
| Falmouth (C. & G. S. and Borden). | 41 35 53.114 | 1638.6 | 70 37 05.477 | 126.9 |
| Naushon. | 41 29 25.030 | 772.2 | 70 44 33.380 | 774.4 |
| Mishaum Point. | 41 30 56.112 | 1731.1 | 70 57 16.438 | 381.1 |
| Swift's Hill. | 41 34 02.457 | 75.7 | 70 38 30.704 | 711.3 |
| West Island. | 41 34 56.619 | 1746.6 | 70 49 20.791 | 481.5 |
| Angelica Point. | 41 38 28.974 | 894.0 | 70 45 55.351 | 1280.9 |
| Pine Hill (C. & G. S. and Borden). | 41 42 31.126 | 960.2 | 70 33 58.608 | 1354.9 |
| Wood's Holl. | 41 31 38.796 | 1196.9 | 70 39 41.578 | 964.0 |
| Great Hill (C. & G. S. and Borden). | 41 42 33.278 | 1026.6 | 70 43 20.441 | 472.8 |
| Mendal (Borden). | 41 42 03.029 | 93.4 | 70 53 00.021 | 0.5 |
| New Bedford court house (Borden). | 41 38 03.723 | 114.9 | 70 55 52.961 | 1225.9 |
| Dartmouth (C. & G. S. and Borden). | 41 34 11.594 | 357.7 | 71 01 47.538 | 1101.4 |

**MARTHA'S VINEYARD AND VINEYARD SOUND**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 1 44 18 | 181 44 01 | Sampson | 20049.3 | 4.30210 |
| 49 35 50 | 229 27 50 | Indian. | 22088.2 | 4.34416 |
| 240 17 24 | 60 24 06 | Hyannis | 16123.2 | 4.20745 |
| 109 46 24 | 289 40 43 | Falmouth. | 12645.3 | 4.10193 |
| 46 31 14 | 226 28 20 | Indian | 8404.8 | 3.92453 |
| 94 45 47 | 274 40 19 | Naushon. | 11530.5 | 4.06185 |
| 29 46 21 | 209 45 02 | Sampson (Borden) | 5580.3 | 3.74666 |
| 92 42 02 | 272 33 01 | Indian. | 18997.7 | 4.27870 |
| 309 38 06 | 129 42 56 | Sampson | 13207.2 | 4.12081 |
| 65 44 56 | 245 42 04 | Indian. | 6634.4 | 3.82180 |
| 222 49 07 | 42 54 18 | Succonnesset (Borden) | 15991.6 | 4.20389 |
| 231 32 49 | 51 44 41 | Hyannis. | 31745.9 | 4.50169 |
| 46 47 36 | 226 44 37 | Indian | 8598.4 | 3.93442 |
| 94 11 22 | 274 05 48 | Naushon. | 11690.4 | 4.06783 |
| 95 45 48 | 275 40 17 | Desert Hill | 11665.9 | 4.06692 |
| 133 03 46 | 313 01 21 | Davis Hill. | 6926.9 | 3.84054 |
| 249 06 38 | 69 12 08 | Hyannis | 12327.9 | 4.090888 |
| 7 42 26 | 187 40 54 | Sampson. | 23949.7 | 4.379300 |

**BUZZARD'S BAY.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| 183 30 32.8 | 3 31 37.5 | Manomet | 36646.7 | 4.564035 |
| 246 40 36.4 | 66 51 24.7 | Shootflying. | 24574.7 | 4.390489 |
| 64 18 42.8 | 244 11 06.5 | Cuttyhunk | 17761.7 | 4.249485 |
| 220 53 15.1 | 40 58 12.1 | Falmouth. | 15846.9 | 4.199944 |
| 278 57 06.3 | 99 05 31.9 | Naushon | 17919.2 | 4.253320 |
| 350 45 14.3 | 170 46 03.2 | Cuttyhunk. | 10665.3 | 4.027971 |
| 77 40 44.5 | 257 28 17.9 | Mishaum Point | 26719.4 | 4.426827 |
| 44 31 29.2 | 224 27 28.7 | Naushon. | 11997.9 | 4.079106 |
| 276 16 15.3 | 96 23 26.7 | Swift's Hill | 15153.1 | 4.180503 |
| 264 05 20.4 | 84 13 28.5 | Falmouth. | 17120.1 | 4.233507 |
| 308 34 05.4 | 128 39 00.6 | Swift's Hill | 13176.7 | 4.119807 |
| 291 21 18.3 | 111 27 10.2 | Falmouth. | 13176.0 | 4.119784 |
| 277 59 36.0 | 98 08 20.8 | Shootflying | 18423.8 | 4.265378 |
| 175 08 52.8 | 355 07 53.1 | Manomet. | 24386.1 | 4.387143 |
| 87 00 55.3 | 266 49 16.1 | Mishaum Point | 24493.7 | 4.389055 |
| 114 30 11.1 | 294 23 47.0 | West Island. | 14745.2 | 4.168651 |
| 28 56 16.9 | 208 47 51.3 | Cuttyhunk | 36580.9 | 4.563254 |
| 324 51 59.0 | 144 56 08.2 | Falmouth. | 15089.5 | 4.178675 |
| 7 45 54.3 | 187 43 53.1 | Cuttyhunk | 31388.6 | 4.496772 |
| 297 14 08.2 | 117 24 42.6 | Falmouth. | 24862.7 | 4.395548 |
| 0 32 35.8 | 180 32 29.4 | Cuttyhunk | 23720.2 | 4.375118 |
| 278 40 15.8 | 98 52 44.6 | Falmouth. | 26413.3 | 4.421821 |
| 334 10 48.7 | 154 14 37.2 | Cuttyhunk | 18389.0 | 4.264559 |
| 264 39 02.7 | 84 55 26.4 | Falmouth. | 34473.0 | 4.537479 |

BUZZARD'S BAY—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Eldridge. | 41 31 46.109 | 1422.4 | 71 05 08.269 | 191.7 |
| Gooseberry Neck. | 41 29 20.083 | 619.6 | 71 02 19.612 | 455.0 |
| Almy. | 41 30 42.286 | 1304.5 | 71 01 49.855 | 1156.0 |
| Quicksand. | 41 30 01.683 | 51.9 | 71 07 12.194 | 282.8 |
| Nootas (Borden). | 41 32 13.094 | 404.0 | 71 07 25.874 | 599.8 |
| Pasque. | 41 26 57.82 | 1783.8 | 70 50 04.43 | 102.8 |
| Sconticut Neck. | 41 35 02.65 | 81.7 | 70 51 20.39 | 472.2 |
| Round Hill. | 41 32 24.79 | 764.9 | 70 55 50.59 | 1172.6 |
| Clark's Point. | 41 35 34.15 | 1053.1 | 70 54 03.69 | 85.4 |
| New Bedford Fort. | 41 37 27.06 | 834.9 | 70 54 10.37 | 240.0 |
| Wild Harbor. | 41 38 22.19 | 684.7 | 70 39 09.05 | 209.5 |
| Wenaumet Neck. | 41 40 58.14 | 1793.7 | 70 39 41.00 | 948.2 |
| Sippican Neck. | 41 40 35.93 | 1108.4 | 70 42 58.05 | 1342.6 |
| Tempes Knob. | 41 42 58.46 | 1803.6 | 70 39 48.84 | 1128.9 |
| Indian Neck. | 41 43 33.27 | 1026.4 | 70 41 27.05 | 625.2 |
| Cromeset Neck. | 41 43 41.74 | 1287.6 | 70 43 20.57 | 475.5 |
| Long Neck. | 41 44 20.21 | 623.6 | 70 38 45.42 | 1049.5 |
| Back River Harbor. | 41 43 18.58 | 573.3 | 70 36 50.49 | 1167.0 |
| Hog Island Harbor. | 41 36 15.84 | 488.6 | 70 38 57.00 | 1319.8 |
| Nashawena. | 41 25 30.97 | 955.4 | 70 52 06.61 | 153.5 |
| Naushon, southwest. | 41 27 01.82 | 56.1 | 70 47 19.97 | 463.5 |
| Naushon, northeast. | 41 30 35.72 | 1101.7 | 70 42 48.91 | 1134.2 |
| Penikese. | 41 26 58.17 | 1794.6 | 70 55 26.91 | 624.7 |

**BUZZARD'S BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 104 36 20.2 | 284 34 49.0 | Nootas | 3295.3 | 3.517897 |
| 46 13 00.8 | 226 08 42.4 | East Rock. | 12540.9 | 4.098329 |
| 247 07 31.1 | 67 10 52.0 | Mishaum Point | 7630.2 | 3.882535 |
| 310 48 37.4 | 130 52 47.0 | Cuttyhunk. | 11566.0 | 4.063182 |
| 63 52 05.2 | 243 45 35.4 | East Rock | 15214.7 | 4.182265 |
| 321 23 15.1 | 141 27 05.0 | Cuttyhunk. | 12920.4 | 4.111276 |
| 221 43 16.3 | 41 44 38.4 | Eldridge | 4317.0 | 3.635184 |
| 175 32 19.6 | 355 32 10.6 | Nootas. | 4064.2 | 3.608975 |
| 244 58 18.0 | 65 02 02.4 | Dartmouth | 8651.3 | 3.937081 |
| 309 04 44.8 | 129 12 17.3 | Cuttyhunk. | 20438.7 | 4.310454 |
| 69 08 02 | 249 04 05 | Cuttyhunk | 8902.3 | 3.94950 |
| 126 17 56 | 306 13 10 | Mishaum Point. | 12429.7 | 4.09446 |
| 317 47 31 | 137 52 01 | Naushon | 14053.7 | 4.14779 |
| 19 52 38 | 199 49 31 | Cuttyhunk. | 19277.9 | 4.28506 |
| 289 23 19 | 109 30 48 | Naushon | 16654.1 | 4.22152 |
| 232 05 55 | 52 08 54 | Sconticut Neck. | 7932.1 | 3.89939 |
| 284 23 43 | 104 25 31 | Sconticut Neck | 3905.4 | 3.59166 |
| 22 59 12 | 202 58 01 | Round Hill. | 6345.4 | 3.80246 |
| 318 31 21 | 138 33 14 | Sconticut Neck | 5945.0 | 3.77415 |
| 357 27 24 | 177 27 28 | Clark's Point. | 3486.7 | 3.54241 |
| 65 56 09 | 245 49 23 | West Island | 15519.6 | 4.19088 |
| 353 40 19 | 173 40 44 | Swift's Hill. | 8062.0 | 3.90644 |
| 352 45 42 | 172 46 29 | Swift's Hill | 12927.1 | 4.11150 |
| 62 03 03 | 241 58 54 | Angelica Point. | 9807.5 | 3.99156 |
| 46 20 26 | 226 18 28 | Angelica Point | 5671.8 | 3.75372 |
| 171 51 55 | 351 51 40 | Great Hill. | 3657.1 | 3.56314 |
| 44 52 33 | 224 50 27 | Sippican Neck | 6203.1 | 3.79261 |
| 80 59 49 | 260 57 28 | Great Hill. | 4952.8 | 3.69485 |
| 295 19 04 | 115 20 09 | Tempes Knob | 2511.5 | 3.39993 |
| 54 46 40 | 234 45 24 | Great Hill. | 3208.6 | 3.50631 |
| 275 40 40 | 95 41 56 | Indian Neck | 2636.5 | 3.42102 |
| 359 55 02 | 179 55 02 | Great Hill. | 2112.5 | 3.32479 |
| 296 53 16 | 116 56 27 | Pine Hill | 7434.8 | 3.87127 |
| 62 35 50 | 242 32 47 | Great Hill. | 7162.1 | 3.85504 |
| 290 12 39 | 110 14 33 | Pine Hill | 4234.9 | 3.62684 |
| 81 13 19 | 261 09 00 | Great Hill. | 9122.2 | 3.96010 |
| 351 34 38 | 171 34 56 | Swift's Hill | 4159.7 | 3.61906 |
| 80 27 22 | 260 20 28 | West Island. | 14652.4 | 4.16591 |
| 192 24 47 | 12 26 37 | West Island | 17869.8 | 4.25212 |
| 235 29 35 | 55 34 35 | Naushon. | 12758.5 | 4.10580 |
| 117 38 05 | 297 31 29 | Mishaum Point | 15612.1 | 4.19346 |
| 169 11 04 | 349 09 44 | West Island. | 14913.2 | 4.17357 |
| 131 34 55 | 311 30 35 | West Island | 12135.8 | 4.08407 |
| 223 09 26 | 43 12 18 | Swift's Hill. | 8746.4 | 3.94183 |
| 270 03 07 | 90 06 40 | Pasque | 7485.3 | 3.87421 |
| 14 36 00 | 194 35 36 | Cuttyhunk. | 3292.5 | 3.51753 |

**BUZZARD'S BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Penikese (Borden). | 41 26 58.19 | 1795.3 | 70 55 27.10 | 629.1 |
| Padanaram. | 41 35 39.27 | 1211.4 | 70 56 35.73 | 827.5 |
| Padanaram, gray spire. | 41 35 20.12 | 620.8 | 70 56 28.07 | 650.1 |
| New Bedford Baptist church. | 41 38 12.37 | 381.6 | 70 55 36.98 | 855.9 |
| New Bedford Beacon. | 41 36 33.62 | 1037.2 | 70 53 28.73 | 665.2 |
| Fair Haven, black spire. | 41 38 09.81 | 302.6 | 70 54 18.85 | 436.2 |
| Pamanset River. | 41 31 41.30 | 1274.0 | 70 59 30.99 | 718.5 |
| Monument church. | 41 44 32.45 | 1001.1 | 70 35 49.73 | 1149.1 |
| Pocasset spire. | 41 41 41.55 | 1281.8 | 70 36 18.28 | 422.7 |
| South Pocasset spire. | 41 40 36.28 | 1119.2 | 70 36 22.83 | 528.1 |
| Scraggy Neck. | 41 39 59.28 | 1828.8 | 70 39 15.57 | 360.1 |
| North Falmouth, spire. | 41 38 33 32 | 1027.9 | 70 37 07.29 | 168.7 |
| Falmouth, spire. | 41 33 14.95 | 461.2 | 70 37 12.52 | 290.1 |
| Mattapoisett Neck. | 41 37 46.57 | 1436.7 | 70 48 11.30 | 261.5 |
| Mattapoisett, gray spire. | 41 39 43.93 | 1355.2 | 70 49 12.28 | 284.1 |
| Sippican church. | 41 42 09.92 | 306.0 | 70 45 47.88 | 1107.0 |
| Wareham Baptist church. | 41 45 27.19 | 838.9 | 70 43 03.63 | 83.8 |
| Charles Neck. | 41 40 21.61 | 666.7 | 70 44 45.04 | 1041.8 |
| West Island 2. | 41 35 25.09 | 774.1 | 70 49 04.85 | 112.3 |
| New Falmouth. | 41 33 42.42 | 1308.7 | 70 37 52.42 | 1214.6 |
| Ned's Point light-house, 1844. | 41 39 03.34 | 103.0 | 70 47 46.11 | 1067.0 |
| Dumpling Rock (Round Hill) light-house. (C. & G. S. & B.), 1835–'44. | 41 32 17.88 | 551.6 | 70 55 19.09 | 442.5 |
| Clark's Point light-house (C. & G. S. & B.). 1835–'44. | 41 35 34.28 | 1057.5 | 70 54 03.91 | 90.5 |

**BUZZARD'S BAY—Continued.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 276 01 55 | 96 11 43 | Indian | 20695.7 | 4.31588 |
| 14 31 35 | 194 31 12 | Cuttyhunk. | 3292.2 | 3.51748 |
| 272 33 21 | 92 35 02 | Clark's Point | 3524.9 | 3.54715 |
| 350 06 28 | 170 06 58 | Round Hill. | 6090.5 | 3.78465 |
| 262 36 50 | 82 38 26 | Clark's Point | 3372.1 | 3.52790 |
| 350 52 30 | 170 52 55 | Round Hill. | 5478.6 | 3.73867 |
| 316 33 12 | 136 40 33 | Naushon | 22385.1 | 4.34996 |
| 9 43 15 | 189 42 09 | Mishaum Point. | 13654.9 | 4.13529 |
| 313 20 41 | 133 22 06 | Sconticut Neck | 4087.9 | 3.61150 |
| 23 49 00 | 203 48 37 | Clark's Point. | 2005.3 | 3.30218 |
| 324 23 42 | 144 25 41 | Sconticut Neck | 7100.2 | 3.85127 |
| 355 49 08 | 175 49 18 | Clark's Point. | 4815.2 | 3.68261 |
| 255 15 59 | 75 18 25 | Round Hill | 5282.3 | 3.72282 |
| 294 03 39 | 114 05 08 | Mishaum Point. | 3417.3 | 3.53368 |
| 31 38 53 | 211 38 12 | Back River Harbor | 2676.6 | 3.42759 |
| 84 42 15 | 264 40 18 | Long Neck. | 4077.2 | 3.61036 |
| 110 50 11 | 290 45 30 | Cromeset Neck | 10442.9 | 4.01882 |
| 115 48 03 | 295 44 38 | Indian Neck. | 7026.7 | 3.89909 |
| 89 58 14 | 269 53 51 | Sippican Neck | 9142.0 | 3.96104 |
| 132 39 30 | 312 37 13 | Tempes Knob. | 6475.7 | 3.81129 |
| 357 07 03 | 177 07 07 | Wild Harbor | 2999.2 | 3.47700 |
| 102 24 46 | 282 22 18 | Sippican Neck. | 5269.3 | 3.72175 |
| 115 01 26 | 294 57 33 | Sippican Neck | 8953.6 | 3.95200 |
| 89 25 16 | 269 19 25 | Angelica Point. | 12221.9 | 4.08714 |
| 49 21 48 | 229 20 09 | Wood's Holl | 4552.6 | 3.65826 |
| 55 16 57 | 235 12 05 | Naushon. | 12442.6 | 4.09491 |
| 297 09 35 | 117 16 00 | Swift's Hill | 15119.6 | 4.17954 |
| 341 54 20 | 161 56 45 | Naushon. | 16276.1 | 4.21155 |
| 305 17 09 | 125 24 15 | Swift's Hill | 18210.8 | 4.26033 |
| 1 16 23 | 181 16 17 | West Island. | 8866.3 | 3.94774 |
| 284 35 42 | 104 39 46 | Wenaumet Neck | 8768.4 | 3.94292 |
| 326 01 32 | 146 06 22 | Swift's Hill. | 18125.9 | 4.25830 |
| 294 40 30 | 114 44 38 | Back River Harbor | 9491.8 | 3.97735 |
| 330 32 52 | 150 35 07 | Wenaumet Neck. | 9530.8 | 3.97913 |
| 295 19 33 | 115 23 16 | Wild Harbor | 8603.0 | 3.93465 |
| 25 05 27 | 205 04 40 | Angelica Point. | 3836.7 | 3.58396 |
| 217 42 03 | 37 44 09 | Angelica Point | 7171.5 | 3.85561 |
| 298 05 11 | 118 11 25 | Wood's Holl. | 14802.3 | 4.17033 |
| 33 34 24 | 213 33 12 | Wood's Holl | 4576.6 | 3.66054 |
| 49 32 05 | 229 27 39 | Naushon. | 12225.6 | 4.08727 |
| 305 46 12 | 125 52 21 | Swift's Hill | 15860.2 | 4.20031 |
| 345 55 52 | 165 58 00 | Naushon. | 18391.6 | 4.26462 |
| 4 26 03 | 184 25 34 | Cuttyhunk | 13088.5 | 4.11689 |
| 47 10 39 | 227 09 21 | Mishaum Point. | 3710.5 | 3.56943 |
| 280 00 58 | 100 04 06 | West Island | 6660.2 | 3.82349 |
| 27 29 12 | 207 27 04 | Mishaum Point. | 9672.1 | 3.98552 |

**BUZZARD'S BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Bird Island light-house (C. & G. S. & B.). 1835–'44. | 41 40 09.65 | 297.6 | 70 43 04.14 | 95.8 |
| Cuttyhunk light-house (C. & G. S. & B.).* 1835–'44. | 41 24 52.36 | 1615.3 | 70 57 00.18 | 4.2 |
| Naushon (Borden). | 41 29 24.97 | 770.4 | 70 44 33.34 | 773.4 |
| Wing's Neck light-house, 1875. | 41 40 49.38 | 1523.4 | 70 39 41.75 | 965.6 |
| Palmer's Island light-house, 1875. | 41 37 37.27 | 1149.7 | 70 54 34.72 | 803.7 |
| Quicksand (Borden). | 41 30 01.73 | 53.4 | 71 07 12.18 | 282.5 |
| Joe Sanford (Borden). | 41 35 37.56 | 1158.7 | 71 07 55.53 | 1286.1 |

**TAUNTON RIVER.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| Pine Hill (Rhode Island). | 41 38 00.469 | 14.5 | 71 20 35.806 | 828.7 |
| Mount Hope 2 (Rhode Island). 1874. | 41 40 26.515 | 818.0 | 71 14 26.094 | 603.6 |
| Hog Island 3 (Rhode Island). 1874. | 41 38 40.481 | 1248.8 | 71 16 50.822 | 1176.0 |
| Mound (Rhode Island). | 41 38 14.042 | 433.2 | 71 13 11.906 | 275.4 |
| Chase. | 41 40 23.917 | 737.9 | 71 11 16.462 | 380.9 |
| Gardner's Neck. | 41 42 33.742 | 1040.9 | 71 12 24.807 | 573.5 |
| City. | 41 41 43.770 | 1350.3 | 71 10 19.091 | 441.4 |
| Somerset 2. 1874. | 41 43 44.048 | 1358.9 | 71 10 08.164 | 188.7 |
| Calvary. | 41 43 40.822 | 1259.4 | 71 08 05.039 | 116.4 |
| Steep Brook. | 41 44 56.972 | 1757.6 | 71 07 23.164 | 535.2 |
| Wood. | 41 45 03.097 | 95.5 | 71 08 27.346 | 631.8 |
| Bluff. | 41 45 54.516 | 1681.9 | 71 07 49.704 | 1148.1 |
| Burns. | 41 44 26.702 | 823.8 | 71 08 52.719 | 1218.2 |
| Ridge. | 41 45 33.464 | 1032.4 | 71 07 10.982 | 253.7 |

BUZZARD'S BAY—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 330 46 42 | 150 49 44 | Swift's Hill | 12977.5 | 4.11319 |
| 42 06 35 | 222 02 25 | West Island. | 13911.3 | 4.11432 |
| 133 10 45 | 313 03 51 | Nootas | 19888.9 | 4.29861 |
| 178 04 33 | 358 04 22 | Mishaum Point. | 11228.7 | 4.05033 |
| 135 31 30 | 315 23 59 | New Bedford court-house | 22452.8 | 4.35127 |
| 110 20 25 | 290 08 59 | Dartmouth. | 25555.2 | 4.40748 |
| 2 48 50 | 182 48 11 | Indian | 27881.8 | 4.44532 |
| 17 10 04 | 197 06 58 | Desert Hill. | 21973.5 | 4.34190 |
| 334 55 53 | 155 02 20 | Prospect Chilmark | 32016.2 | 4.50537 |
| 316 37 24 | 136 44 11 | Desert Hill. | 20716.7 | 4.31632 |
| 175 31 13 | 355 31 04 | Nootas (Borden) | 4065.1 | 3.60907 |
| 299 36 00 | 119 43 23 | Cuttyhunk. | 17881.7 | 4.25241 |
| 353 46 48 | 173 47 08 | Nootas (Borden) | 6345.6 | 3.80247 |
| 83 08 51 | 263 03 57 | Quaker. | 10331.1 | 4.01415 |

TAUNTON RIVER.

| | | | | |
|---|---|---|---|---|
| 31 55 58.6 | 211 51 27.3 | McSparran | 17933.0 | 4.253654 |
| 307 30 33.8 | 127 34 04.6 | Quaker. | 9270.7 | 3.967114 |
| 62 15 31.6 | 242 11 25.8 | Pine Hill | 9668.8 | 3.985375 |
| 6 47 47.5 | 186 47 12.8 | Quaker. | 10226.1 | 4.009711 |
| 342 42 37.5 | 162 43 38.9 | Quaker | 7208.4 | 3.857842 |
| 225 39 19.2 | 45 40 55.4 | Mount Hope 2. | 4681.3 | 3.670366 |
| 157 13 25.6 | 337 12 36.3 | Mount Hope 2 | 4432.8 | 3.646681 |
| 25 46 07.3 | 205 44 43.3 | Quaker. | 6736.7 | 3.828449 |
| 33 42 01.7 | 213 40 45.0 | Mound | 4815.6 | 3.682651 |
| 91 03 50.6 | 271 01 44.5 | Mount Hope 2. | 4387.3 | 3.642195 |
| 7 44 52.7 | 187 44 21.4 | Mound | 8085.9 | 3.907727 |
| 338 27 33.1 | 158 28 18.6 | Chase. | 4305.9 | 3.634060 |
| 117 57 10.9 | 297 55 47.3 | Gardner's Neck | 3290.3 | 3.517238 |
| 67 22 33.6 | 247 19 49.3 | Mount Hope 2. | 6189.9 | 3.791686 |
| 44 24 16.2 | 224 21 24.6 | Mount Hope 2 | 8526.8 | 3.930786 |
| 3 53 43.5 | 183 53 36.2 | City. | 3719.3 | 3.570466 |
| 92 00 50.6 | 271 59 28.7 | Somerset 2 | 2847.4 | 3.454456 |
| 71 00 27.8 | 250 57.34.9 | Gardner's Neck. | 6351.4 | 3.802868 |
| 22 23 25.9 | 202 22 58.0 | Calvary | 2540.8 | 3.404971 |
| 59 28 21.2 | 239 26 31.4 | Somerset 2. | 4427.2 | 3.646127 |
| 277 15 24.1 | 97 16 06.8 | Steep Brook | 1494.9 | 3.174610 |
| 348 31 06.4 | 168 31 21.2 | Calvary. | 2590.1 | 3.413318 |
| 28 44 00.6 | 208 43 35.5 | Wood | 1809.1 | 3.257462 |
| 340 56 43.0 | 160 57 00.7 | Steep Brook. | 1878.3 | 3.273754 |
| 245 42 09.5 | 65 43 09.1 | Steep Brook | 2270.3 | 3.356075 |
| 208 14 48.9 | 28 15 30.8 | Bluff. | 3075.6 | 3.487933 |
| 125 59 14.1 | 305 58 48.3 | Bluff | 1105.4 | 3.043521 |
| 48 46 57.4 | 228 45 49.8 | Burns. | 3125.4 | 3.494898 |

**TAUNTON RIVER**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Depot. | 41 46 31.092 | 959.3 | 71 07 15.068 | 348.0 |
| Terry. | 41 46 31.456 | 970.5 | 71 06 43.069 | 994.7 |
| Richmond Hill. | 41 48 27.290 | 841.9 | 71 07 43.348 | 1000.6 |
| Mack. | 41 47 30.986 | 956.0 | 71 07 02.325 | 53.7 |
| Marsh. | 41 47 38.184 | 1178.0 | 71 07 33.802 | 780.5 |
| Nichols. | 41 48 25.970 | 801.2 | 71 06 59.357 | 1370.2 |
| New. | 41 49 33.063 | 1020.1 | 71 06 58.418 | 1348.2 |
| Bare Top. | 41 48 52.846 | 1630.4 | 71 06 00.440 | 10.2 |
| Assonet. | 41 47 25.348 | 782.1 | 71 05 56.878 | 1313.3 |
| Graveyard. | 41 49 34.476 | 1063.7 | 71 07 28.940 | 667.8 |
| Schoolhouse Hill. | 41 50 01.412 | 43.6 | 71 06 17.556 | 405.1 |
| Beveled Barn, ball on cupola. | 41 50 12.731 | 392.8 | 71 07 09.139 | 210.9 |
| Telegraph. | 41 50 59.358 | 1831.3 | 71 06 50.326 | 1160.9 |
| Florence. | 41 50 45.033 | 1389.4 | 71 06 58.033 | 1338.8 |
| High. | 41 50 57.520 | 1774.6 | 71 06 29.891 | 689.6 |
| Brown's Hill. | 41 47 25.291 | 780.3 | 71 06 27.655 | 638.6 |
| Blackbeard. | 41 40 28.88 | 891.0 | 71 10 58.83 | 1360.8 |
| Fall River. | 41 42 39.25 | 1210.9 | 71 08 45.54 | 1052.8 |
| Fall River 2. 1861. | 41 42 39.74 | 1226.0 | 71 08 45.38 | 1049.1 |
| Mattapoisett. | 41 42 40.47 | 1248.6 | 71 12 51.76 | 1196.6 |
| Globe Village chimney. | 41 41 17.27 | 532.8 | 71 10 23.84 | 551.3 |
| Slade. | 41 43 41.20 | 1271.1 | 71 10 09.12 | 210.8 |
| Somerset. | 41 44 07.60 | 234.5 | 71 10 06.49 | 150.0 |

**TAUNTON RIVER**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 356 57 38.7 | 176 57 41.4 | Ridge | 1780.4 | 3.250528 |
| 30 27 26.5 | 210 26 21.4 | Burns. | 4451.6 | 3.648517 |
| 53 29 11.9 | 233 28 27.4 | Bluff | 1915.1 | 3.282192 |
| 89 07 59.4 | 269 07 38.1 | Depot. | 739.1 | 2.868720 |
| 349 40 28.9 | 169 40 47.7 | Depot | 3643.9 | 3.561567 |
| 338 42 55.8 | 158 43 36.0 | Terry. | 3835.2 | 3.583785 |
| 151 24 14.9 | 331 23 47.5 | Richmond Hill | 1978.5 | 3.296337 |
| 346 23 17.4 | 166 23 30.3 | Terry. | 1889.7 | 3.276386 |
| 286 59 19.2 | 106 59 40.2 | Mack | 760.0 | 2.880792 |
| 171 43 29.2 | 351 43 22.8 | Richmond Hill. | 1531.0 | 3.184964 |
| 92 18 06.1 | 272 17 36.8 | Richmond Hill | 1016.3 | 3.007025 |
| 28 20 44.5 | 208 20 21.5 | Marsh. | 1675.1 | 3.224034 |
| 27 04 23.4 | 207 03 53.4 | Richmond Hill | 2278.9 | 3.357718 |
| 0 36 00.7 | 180 36 00.1 | Nichols. | 2070.1 | 3.315990 |
| 132 50 39.4 | 312 50 00.8 | New | 1824.8 | 3.261220 |
| 71 38 48.7 | 251 37 40.1 | Richmond Hill. | 2502.8 | 3.398432 |
| 127 52 24.6 | 307 51 13.6 | Richmond | 3113.5 | 3.493253 |
| 178 15 22.1 | 358 15 19.7 | Bare Top. | 2700.8 | 3.431485 |
| 9 06 57.6 | 189 06 48.0 | Richmond Hill | 2099.4 | 3.322089 |
| 302 09 17.4 | 122 10 16.4 | Bare Top. | 2412.8 | 3.382516 |
| 63 14 12.5 | 243 13 24.9 | Graveyard | 1845.0 | 3.266001 |
| 34 17 48.5 | 214 16 51.3 | Richmond Hill. | 3514.7 | 3.545888 |
| 21 09 55.2 | 201 09 42.0 | Graveyard | 1265.6 | 3.102298 |
| 286 20 51.3 | 106 21 25.7 | School-house Hill. | 1240.4 | 3.093570 |
| 16 47 28.6 | 196 47 16.1 | Beveled Barn | 1502.6 | 3.176844 |
| 337 04 22.0 | 157 04 43.9 | School-house Hill. | 1941.1 | 3.288045 |
| 14 25 12.9 | 194 25 05.5 | Beveled Barn | 1029.0 | 3.012409 |
| 201 54 48.2 | 21 54 53.3 | Telegraph. | 476.4 | 2.677972 |
| 96 51 41.2 | 276 51 27.6 | Telegraph | 474.8 | 2.676518 |
| 59 18 59.4 | 239 18 40.7 | Florence. | 754.9 | 2.877910 |
| 34 05 25.2 | 214 04 30.5 | Bluff | 3381.4 | 3.529096 |
| 137 35 32.0 | 317 34 41.5 | Richmond Hill. | 2590.9 | 3.413448 |
| 17 33 47 | 197 33 25 | Pocasset | 2571.2 | 3.41014 |
| 89 00 23 | 268 58 05 | Mount Hope. | 4797.7 | 3.68103 |
| 62 29 50 | 242 26 03 | Mount Hope | 8884.4 | 3.94863 |
| 30 48 42 | 210 46 51 | Pocasset. | 7536.0 | 3.87714 |
| 37 24 38 | 217 23 09 | Blackbeard | 5081.7 | 3.70601 |
| 62 25 28 | 242 21 41 | Mount Hope. | 8894.5 | 3.94912 |
| 327 14 22 | 147 15 37 | Blackbeard | 4827.4 | 3.68371 |
| 27 47 47 | 207 46 44 | Mount Hope. | 4685.0 | 3.67071 |
| 74 18 11 | 254 15 30 | Mount Hope | 5823.7 | 3.76520 |
| 126 53 58 | 306 52 20 | Mattapoisett. | 4276.5 | 3.63109 |
| 12 56 22 | 192 55 27 | Pocasset | 8603.2 | 3.93466 |
| 44 40 17 | 224 37 26 | Mount Hope. | 8459.0 | 3.92732 |
| 325 19 15 | 145 20 09 | Fall River 2 | 3295.8 | 3.51796 |
| 41 20 10 | 221 17 17 | Mount Hope. | 9096.2 | 3.95886 |

**TAUNTON RIVER**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Fall River spire, 1861. | 41 42 06.87 | 211.9 | 71 09 15.00 | 346.8 |
| Fall River tower, 1861. | 41 42 00.87 | 26.7 | 71 09 25.42 | 587.7 |
| Fall River derrick. | 41 42 19.32 | 596.0 | 71 09 56.72 | 1311.4 |
| Dodge's stable, turret. | 41 40 56.33 | 1737.9 | 71 10 40.24 | 930.7 |
| Durfee cupola. | 41 42 36.36 | 1121.8 | 71 09 04.82 | 111.4 |
| Swanzey belfry, 1843–61. | 41 45 03.22 | 99.3 | 71 13 30.90 | 713.9 |
| Somerset meeting-house, 1843. | 41 44 11.54 | 356.0 | 71 10 06.89 | 159.2 |
| Somerset spire, 1861–74. | 41 44 11.64 | 359.1 | 71 10 06.86 | 158.5 |
| Somerset spire. | 41 46 17.88 | 551.7 | 71 07 38.87 | 897.8 |
| Beacon. | 41 42 16.82 | 518.9 | 71 10 29.71 | 686.9 |
| Large chimney with rail on top. | 41 42 13.60 | 419.5 | 71 09 52.38 | 1211.0 |
| White barn with square window, cupola. | 41 43 28.38 | 875.6 | 71 09 43.70 | 1010.0 |
| Ferry wharf chimney. | 41 42 34.30 | 1058.2 | 71 10 46.90 | 1084.2 |
| Mill with conical cupola, chimney. | 41 43 06.66 | 205.5 | 71 09 22.27 | 514.8 |
| White church spire. | 41 45 08.92 | 275.5 | 71 08 32.06 | 740.7 |
| Steep Brook church. | 41 44 30.40 | 937.8 | 71 07 46.13 | 1065.8 |
| Assonet flat topped church, west gable chimney. | 41 47 30.26 | 933.6 | 71 04 15.24 | 351.8 |
| Farm-house, white chimney. | 41 48 30.40 | 937.9 | 71 04 53.04 | 1224.3 |
| Assonet spire. | 41 47 45.95 | 1417.8 | 71 04 08.00 | 184.7 |
| North Dighton. | 41 51 14.52 | 448.0 | 71 06 39.39 | 908.7 |
| Meadow. | 41 51 11.22 | 346.2 | 71 06 11.96 | 275.9 |
| River. | 41 51 36.08 | 1113.2 | 71 06 17.02 | 392.5 |
| Burt. | 41 51 28.72 | 886.1 | 71 05 49.61 | 1144.2 |

**TAUNTON RIVER—Continued.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 66 40 21 | 246 36 54 | Mount Hope | 7840.1 | 3.89432 |
| 104 42 21 | 281 39 57 | Mattapoisett. | 5117.4 | 3.70905 |
| 67 14 17 | 247 10 57 | Mount Hope | 7545.7 | 3.87770 |
| 104 23 01 | 284 20 44 | Mattapoisett. | 4925.0 | 3.69241 |
| 60 45 46 | 240 42 47 | Mount Hope | 7143.6 | 3.85392 |
| 176 07 59 | 356 07 53 | Somerset. | 3348.0 | 3.52479 |
| 79 54 51 | 259 52 21 | Mount Hope | 5309.1 | 3.72502 |
| 188 03 03 | 8 03 24 | Slade. | 5137.1 | 3.71072 |
| 61 38 06 | 241 34 32 | Mount Hope | 8448.5 | 3.92678 |
| 143 23 46 | 323 23 03 | Slade. | 2492.1 | 3.39657 |
| 337 25 52 | 157 27 33 | Blackbeard | 9165.2 | 3.96214 |
| 8 30 40 | 188 30 03 | Mount Hope. | 8643.7 | 3.93670 |
| 326 32 10 | 146 33 04 | Fall River | 3412.1 | 3.53302 |
| 40 47 20 | 220 44 27 | Mount Hope. | 9183.1 | 3.96299 |
| 288 38 52 | 108 40 13 | Calvary | 2971.7 | 3.47300 |
| 40 49 02 | 220 46 10 | Mount Hope 2. | 9173.8 | 3.96255 |
| 19 08 10 | 199 08 03 | Bluff | 763.1 | 2.88258 |
| 334 49 03 | 154 49 22 | Ridge. | 1514.3 | 3.18020 |
| 190 29 02 | 10 29 16 | Somerset 2 | 2736.6 | 3.43722 |
| 346 27 34 | 166 27 41 | City. | 1048.9 | 3.02074 |
| 33 52 04 | 213 51 46 | City | 1108.1 | 3.04460 |
| 222 40 14 | 42 41 25 | Calvary. | 3660.5 | 3.56355 |
| 14 13 39 | 194 13 15 | City | 3329.4 | 3.52236 |
| 260 26 02 | 80 27 08 | Calvary. | 2312.6 | 3.36410 |
| 337 35 05 | 157 35 24 | City | 1686.2 | 3.22690 |
| 241 14 14 | 61 16 02 | Calvary. | 4267.4 | 3.63017 |
| 239 26 12 | 59 27 03 | Calvary | 2073.1 | 3.31663 |
| 27 11 38 | 207 11 00 | City. | 2874.9 | 3.45863 |
| 347 03 32 | 167 03 50 | Calvary | 2789.0 | 3.44545 |
| 214 49 32 | 34 50 00 | Bluff. | 1713.4 | 3.23386 |
| 15 56 36 | 195 56 23 | Calvary | 1590.8 | 3.20161 |
| 136 39 13 | 316 38 46 | Wood. | 1387.2 | 3.14213 |
| 136 22 56 | 316 21 46 | Bare Top | 3520.4 | 3.54658 |
| 110 07 57 | 290 05 38 | Richmond Hill. | 5116.8 | 3.70899 |
| 114 00 13 | 293 59 28 | Bare Top | 1702.9 | 3.23119 |
| 88 37 07 | 268 35 13 | Richmond Hill. | 3932.4 | 3.59466 |
| 75 49 35 | 255 48 22 | Assonet | 2593.3 | 3.41384 |
| 104 24 32 | 284 22 09 | Richmond Hill. | 5132.7 | 3.71034 |
| 28 20 12 | 208 20 04 | Telegraph | 351.5 | 2.72552 |
| 337 19 41 | 157 19 47 | High. | 568.5 | 2.75471 |
| 99 09 07 | 279 08 49 | North Dighton | 640.9 | 2.80679 |
| 67 32 27 | 247 32 01 | Telegraph. | 957.7 | 2.98124 |
| 37 48 21 | 217 48 06 | North Dighton | 841.7 | 2.92517 |
| 351 20 31 | 171 20 34 | Meadow. | 775.8 | 2.88975 |
| 43 40 09 | 223 39 54 | Meadow | 746.5 | 2.87302 |
| 109 45 18 | 289 45 00 | River. | 671.7 | 2.82715 |

**TAUNTON RIVER**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Herbert. | 41 51 45.41 | 1401.0 | 71 05 46.99 | 1083.8 |
| Carpenter. | 41 51 36.08 | 1113.2 | 71 05 33.64 | 775.9 |
| Clark. | 41 51 52.70 | 1625.9 | 71 05 13.14 | 303.0 |
| Whitmore. | 41 52 12.51 | 386.0 | 71 05 31.91 | 735.9 |
| Birch. | 41 52 08.52 | 262.8 | 71 05 04.66 | 107.4 |
| Thrasher. | 41 52 22.47 | 693.2 | 71 05 16.73 | 385.8 |
| Hunt. | 41 52 38.99 | 1203.0 | 71 05 30.23 | 697.0 |
| Williams. | 41 52 43.06 | 1328.6 | 71 05 52.70 | 1215.1 |
| Cupola. | 41 52 31.55 | 973.4 | 71 05 48.05 | 1108.0 |
| Schoolhouse. | 41 53 14.12 | 435.6 | 71 05 38.83 | 895.2 |
| Hatch. | 41 53 01.44 | 44.4 | 71 05 13.98 | 322.3 |
| Taunton Iron Works, chimney | 41 52 54.11 | 1669.4 | 71 05 38.55 | 888.8 |
| Johnson. | 41 53 20.81 | 642.0 | 71 04 43.52 | 1003.3 |
| French. | 41 53 35.60 | 1098.4 | 71 05 34.67 | 799.2 |
| Taunton Unitarian spire | 41 54 04.57 | 141.0 | 71 05 19.92 | 459.1 |
| Frederick. | 41 53 41.36 | 1276.2 | 71 04 27.12 | 625.2 |
| Mason. | 41 54 29.24 | 902.2 | 71 04 11.14 | 256.8 |
| Wilbur. | 41 54 40.30 | 1243.4 | 71 05 11.67 | 268.8 |
| Bradford. | 41 54 17.32 | 534.4 | 71 04 38.04 | 876.8 |
| Brickyard. | 41 54 33.09 | 1021.0 | 71 04 45.01 | 1037.3 |
| Briggs | 41 54 56.20 | 1733.9 | 71 03 49.46 | 1139.8 |
| Dean. | 41 54 37.32 | 1151.5 | 71 04 15.35 | 353.7 |
| Hall. | 41 54 22.37 | 690.2 | 71 04 16.29 | 375.5 |

**TAUNTON RIVER**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 6 42 32 | 186 42 30 | Burt | 518.4 | 2.71464 |
| 67 26 24 | 247 26 04 | River. | 750.1 | 2.87511 |
| 58 21 35 | 238 21 24 | Burt | 432.8 | 2.63631 |
| 133 03 51 | 313 03 42 | Herbert. | 421.4 | 2.62473 |
| 42 41 36 | 222 41 22 | Carpenter | 697.3 | 2.84344 |
| 73 56 24 | 253 56 01 | Herbert. | 812.4 | 2.90978 |
| 324 42 10 | 144 42 23 | Clark | 748.9 | 2.87444 |
| 22 35 52 | 202 35 42 | Herbert. | 905.5 | 2.95691 |
| 101 06 18 | 281 06 00 | Whitmore | 640.3 | 2.80639 |
| 21 50 45 | 201 50 39 | Clark. | 525.7 | 2.72074 |
| 327 07 06 | 147 07 14 | Birch | 512.5 | 2.70969 |
| 48 44 38 | 228 44 28 | Whitmore. | 465.7 | 2.66807 |
| 2 42 27 | 182 42 26 | Whitmore | 817.7 | 2.91260 |
| 328 34 19 | 148 34 28 | Thrasher. | 597.3 | 2.77619 |
| 333 02 13 | 153 02 27 | Whitmore | 1057.3 | 3.02418 |
| 283 37 30 | 103 37 45 | Hunt. | 533.0 | 2.72671 |
| 240 47 46 | 60 47 58 | Hunt | 470.6 | 2.67263 |
| 163 12 14 | 343 12 11 | Williams. | 371.0 | 2.56937 |
| 349 38 09 | 169 38 15 | Hunt | 1101.8 | 3.04210 |
| 18 27 19 | 198 27 10 | Williams. | 1010.2 | 3.00440 |
| 124 19 56 | 304 19 39 | Schoolhouse | 693.9 | 2.84126 |
| 57 35 11 | 237 34 45 | Williams. | 1057.6 | 3.02432 |
| 43 44 19 | 223 44 10 | Williams | 471.7 | 2.67363 |
| 337 37 55 | 157 38 01 | Hunt. | 504.3 | 2.70270 |
| 80 48 42 | 260 48 05 | Schoolhouse | 1291.9 | 3.11122 |
| 49 36 14 | 229 35 54 | Hatch. | 922.2 | 2.96483 |
| 8 14 23 | 188 14 20 | Schoolhouse | 669.6 | 2.82583 |
| 291 08 53 | 111 09 27 | Johnson. | 1264.4 | 3.10190 |
| 20 49 46 | 200 49 36 | French | 956.3 | 2.98058 |
| 328 07 57 | 148 08 21 | Johnson. | 1589.6 | 3.20129 |
| 120 28 55 | 300 28 20 | Unitarian spire | 1412.2 | 3.14991 |
| 30 48 59 | 210 48 48 | Johnson. | 738.0 | 2.86805 |
| 14 00 20 | 194 00 09 | Frederick | 1522.4 | 3.18253 |
| 64 22 05 | 244 21 19 | Unitarian spire. | 1758.6 | 3.24517 |
| 330 32 37 | 150 33 07 | Frederick | 2088.4 | 3.31982 |
| 9 47 06 | 189 47 00 | Unitarian spire. | 1118.7 | 3.04870 |
| 132 27 34 | 312 27 12 | Wilbur | 1050.5 | 3.02141 |
| 67 50 14 | 247 49 46 | Unitarian spire. | 1042.3 | 3.01798 |
| 109 55 26 | 289 55 08 | Wilbur | 653.6 | 2.81531 |
| 341 43 51 | 161 43 56 | Bradford. | 512.3 | 2.70949 |
| 75 29 30 | 255 28 35 | Wilbur | 1957.0 | 3.29159 |
| 43 01 34 | 223 01 02 | Bradford. | 1640.9 | 3.21509 |
| 79 11 03 | 259 10 43 | Brickyard | 695.9 | 2.84253 |
| 40 17 00 | 220 16 45 | Bradford. | 808.9 | 2.90787 |
| 182 42 12 | 2 42 13 | Dean | 461.7 | 2.66435 |
| 72 43 37 | 252 43 22 | Bradford. | 524.9 | 2.72006 |

**TAUNTON RIVER—Continued.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Eddy. | 41 54 24.83 | 766.1 | 71 03 58.18 | 1341.0 |
| King. | 41 54 22.66 | 699.1 | 71 03 49.49 | 1140.6 |
| Waterworks. | 41 54 11.20 | 345.6 | 71 03 50.62 | 1166.8 |
| Alex. | 41 54 07.08 | 218.5 | 71 03 34.97 | 806.0 |
| Martin. | 41 54 23.42 | 722.5 | 71 03 28.48 | 656.4 |
| Padelford. | 41 54 08.02 | 247.4 | 71 03 12.26 | 282.6 |
| Henry. | 41 54 23.12 | 713.3 | 71 03 12.80 | 295.0 |
| Pine. | 41 54 12.54 | 386.8 | 71 02 58.18 | 1341.0 |
| Walker. | 41 54 23.22 | 716.4 | 71 02 57.83 | 1332.8 |
| Woods. | 41 54 19.08 | 588.7 | 71 02 44.92 | 1035.3 |
| Edward. | 41 54 10.63 | 327.9 | 71 02 46.50 | 1071.8 |
| Roach. | 41 54 08.44 | 260.3 | 71 02 27.97 | 644.5 |
| Grave. | 41 54 04.71 | 145.1 | 71 02 38.62 | 890.2 |
| Elisha. | 41 53 58.58 | 1807.3 | 71 02 23.21 | 534.8 |
| Cord. | 41 53 56.12 | 1731.4 | 71 02 36.60 | 843.6 |
| Kimball. | 41 53 48.39 | 1493.0 | 71 02 27.11 | 624.7 |
| Elm. | 41 53 51.72 | 1595.7 | 71 02 17.50 | 403.3 |
| Sycamore. | 41 53 37.91 | 1169.7 | 71 02 20.91 | 481.9 |
| Rockheap. | 41 53 44.16 | 1362.5 | 71 02 12.70 | 292.7 |
| Maplewood. | 41 53 27.74 | 855.8 | 71 02 12.91 | 297.5 |
| Stonewall. | 41 53 34.08 | 1051.5 | 71 02 04.19 | 96.6 |
| Washburn. | 41 53 25.41 | 784.0 | 71 01 56.49 | 1302.3 |
| Squawbetty. | 41 53 20.27 | 625.4 | 71 02 05.70 | 131.4 |

**TAUNTON RIVER—Continued.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 79 41 52 | 259 41 40 | Hall | 424.2 | 2.62764 |
| 134 14 33 | 314 14 22 | Dean. | 552.2 | 2.74213 |
| 89 09 53 | 269 09 30 | Hall | 617.8 | 2.79085 |
| 127 11 24 | 307 11 07 | Dean. | 748.0 | 2.87393 |
| 184 13 03 | 4 13 04 | King | 354.6 | 2.54978 |
| 144 44 11 | 324 43 54 | Dean. | 987.0 | 2.99426 |
| 109 26 12 | 289 26 02 | Waterworks | 382.5 | 2.58260 |
| 145 10 31 | 325 10 21 | King. | 585.9 | 2.76785 |
| 87 13 00 | 267 12 46 | King | 484.8 | 2.68552 |
| 16 30 30 | 196 30 26 | Alex. | 526.2 | 2.72116 |
| 141 49 32 | 321 49 21 | Martin | 604.7 | 2.78155 |
| 86 48 50 | 266 48 35 | Alex. | 524.1 | 2.71942 |
| 91 28 52 | 271 28 42 | Martin | 361.4 | 2.55794 |
| 358 27 39 | 178 27 39 | Padelford. | 466.2 | 2.66860 |
| 134 04 48 | 314 04 38 | Henry | 469.1 | 2.67128 |
| 66 42 12 | 246 42 03 | Padelford. | 353.3 | 2.54813 |
| 89 29 00 | 269 28 50 | Henry | 345.0 | 2.53783 |
| 1 23 19 | 181 23 19 | Pine. | 329.5 | 2.51792 |
| 113 14 34 | 293 14 25 | Walker | 323.9 | 2.51035 |
| 56 34 44 | 236 34 35 | Pine. | 366.1 | 2.56361 |
| 146 05 44 | 326 05 36 | Walker | 468.0 | 2.67026 |
| 187 58 22 | 7 58 23 | Woods. | 263.2 | 2.42027 |
| 98 59 14 | 278 59 02 | Edward | 432.3 | 2.63582 |
| 130 02 37 | 310 02 26 | Woods. | 510.1 | 2.70765 |
| 135 09 46 | 315 09 41 | Edward | 257.4 | 2.41069 |
| 244 53 41 | 64 53 48 | Roach. | 271.1 | 2.43316 |
| 118 02 32 | 298 02 22 | Grave | 402.3 | 2.60458 |
| 160 11 07 | 340 11 04 | Roach. | 323.3 | 2.50962 |
| 256 12 23 | 76 12 32 | Elisha | 317.8 | 2.50217 |
| 207 39 06 | 27 39 12 | Roach. | 428.9 | 2.63238 |
| 137 30 30 | 317 30 24 | Cord | 323.7 | 2.51015 |
| 195 58 12 | 15 58 15 | Elisha. | 327.1 | 2.51465 |
| 65 06 39 | 245 06 33 | Kimball | 244.3 | 2.38793 |
| 148 07 26 | 328 07 22 | Elisha. | 249.2 | 2.39658 |
| 190 27 13 | 10 27 15 | Elm | 433.3 | 2.63679 |
| 156 08 24 | 336 08 20 | Kimball. | 353.5 | 2.54839 |
| 111 25 45 | 291 25 35 | Kimball | 357.0 | 2.55264 |
| 44 28 02 | 224 27 57 | Sycamore. | 270.3 | 2.43179 |
| 180 33 26 | 0 33 26 | Rockheap | 506.8 | 2.70481 |
| 149 33 50 | 329 33 45 | Sycamore. | 364.0 | 2.56111 |
| 107 03 15 | 287 03 04 | Sycamore | 403.1 | 2.60538 |
| 45 46 01 | 225 45 55 | Maplewood. | 280.5 | 2.44790 |
| 100 45 14 | 280 45 03 | Maplewood | 385.2 | 2.58571 |
| 146 26 17 | 326 26 12 | Stonewall. | 321.1 | 2.50658 |
| 233 14 00 | 53 14 06 | Washburn | 265.0 | 2.42318 |
| 144 12 05 | 324 12 00 | Maplewood. | 284.2 | 2.45356 |

**TAUNTON RIVER—Continued.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Jesse. | 41 53 11.99 | 370.0 | 71 02 19.21 | 442.8 |
| Hampden. | 41 53 20.15 | 621.6 | 71 02 23.86 | 550.1 |
| Weetamoe. | 41 53 08.94 | 275.9 | 71 02 30.19 | 696.0 |
| Sassacus. | 41 53 19.88 | 613.4 | 71 02 35.87 | 827.0 |
| Canonicus. | 41 53 10.26 | 316.6 | 71 02 47.30 | 1090.5 |
| George. | 41 53 17.58 | 542.4 | 71 02 48.11 | 1109.2 |
| Squawbetty nail-factory, chimney. | 41 53 12.16 | 375.2 | 71 01 54.03 | 1245.7 |
| Squawbetty, white spire. | 41 52 57.37 | 1770.2 | 71 01 39.97 | 921.6 |
| Bryant's Hill. | 41 49 39.79 | 1227.6 | 71 04 43.71 | 1008.7 |
| Pigeon Hill. | 41 50 58.24 | 1796.9 | 70 59 44.57 | 1028.2 |

**MASSACHUSETTS AND RHODE ISLAND BOUNDARY.**

| | | | | |
|---|---|---|---|---|
| Beaconpole (Borden), R. I. | 42 00 03.257 | 100.5 | 71 26 43.159 | 993.2 |
| Red Brush (C. & G. S. and Borden). | 42 01 49.546 | 1528.7 | 71 22 23.459 | 539.6 |
| Oak Hill. | 41 54 51.238 | 1580.8 | 71 16 43.230 | 996.3 |
| Mansfield, old Unitarian church. | 42 01 23.432 | 722.9 | 71 13 04.034 | 92.8 |
| Wing, R. I. | 41 35 23.225 | 716.7 | 71 11 10.352 | 239.8 |
| Paradise Rock, R. I. | 41 30 05.511 | 169.9 | 71 15 45.504 | 1055.3 |
| Simmons 2, R. I. 1870. | 41 29 32.078 | 989.7 | 71 09 34.665 | 804.1 |
| Little Compton 2, R. I. 1870. | 41 31 12.440 | 383.7 | 71 11 01.694 | 39.3 |
| Joe's Rock (Borden). | 42 01 52.99 | 1634.9 | 71 24 17.24 | 396.6 |
| Great Rock (C. & G. S. & B.). | 41 51 32.36 | 998.4 | 71 17 15.47 | 356.8 |
| King's Rock (Borden). | 41 45 22.82 | 704.0 | 71 16 17.27 | 399.0 |

**TAUNTON RIVER—Continued.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 230 37 51 | 50 38 00 | Squawbetty | 402.9 | 2.60524 |
| 196 38 25 | 16 38 29 | Maplewood. | 507.3 | 2.70526 |
| 227 07 27 | 47 07 34 | Maplewood | 344.4 | 2.53711 |
| 336 56 24 | 156 56 27 | Jesse. | 273.6 | 2.43705 |
| 202 52 37 | 22 52 41 | Hampden | 375.3 | 2.57436 |
| 249 36 27 | 69 36 34 | Jesse. | 270.0 | 2.43132 |
| 268 15 21 | 88 15 29 | Hampden | 276.9 | 2.44234 |
| 338 47 35 | 158 47 39 | Weetamoe. | 361.8 | 2.55852 |
| 275 52 15 | 95 52 26 | Weetamoe | 396.6 | 2.59836 |
| 221 36 52 | 41 36 59 | Sassacus. | 397.0 | 2.59875 |
| 255 53 41 | 75 53 49 | Sassacus | 291.2 | 2.46415 |
| 355 15 09 | 175 15 10 | Canonicus. | 226.6 | 2.35523 |
| 172 06 01 | 352 05 59 | Washburn | 412.7 | 2.61564 |
| 132 55 44 | 312 55 36 | Squawbetty. | 367.4 | 2.56515 |
| 156 14 33 | 336 14 22 | Washburn | 945.1 | 2.97549 |
| 139 59 20 | 319 59 03 | Squawbetty. | 922.6 | 2.96501 |
| 352 31 05 | 172 31 50 | Copecut | 11903.6 | 4.07568 |
| 116 28 58 | 296 23 25 | Great Meadow. | 12844.3 | 4.10871 |
| 67 11 06 | 247 05 47 | Richmond Hill | 11989.7 | 4.07881 |
| 100 14 13 | 280 05 21 | Great Meadow. | 18692.2 | 4.27166 |

**MASSACHUSETTS AND RHODE ISLAND BOUNDARY.**

| | | | | |
|---|---|---|---|---|
| 229 16 01.8 | 49 29 20.0 | Blue Hill (Borden) | 36036.0 | 4.556737 |
| 131 55 21.2 | 311 37 08.9 | Hasnebumskit. | 50107.9 | 4.699906 |
| 322 22 16.3 | 142 28 31.5 | Great Meadow | 21193.4 | 4.326202 |
| 58 30 07.5 | 238 27 01.6 | Beaconpole. | 7498.8 | 3.874993 |
| 148 46 29.5 | 328 42 41.9 | Red Brush | 15097.5 | 4.178904 |
| 307 21 19.9 | 127 23 47.4 | Great Meadow. | 6409.0 | 3.806791 |
| 359 51 21.8 | 179 51 23.0 | Great Meadow | 15991.0 | 4.203876 |
| 22 39 42.8 | 202 37 16.2 | Oak Hill. | 13110.8 | 4.117630 |
| 154 08 19.3 | 334 06 09.2 | Mount Hope | 10386.6 | 4.016473 |
| 82 07 08.5 | 262 04 23.9 | Quaker. | 5799.2 | 3.763371 |
| 213 01 28.1 | 33 04 30.6 | Wing | 11693.8 | 4.067957 |
| 314 11 29.3 | 134 14 12.9 | East Rock. | 8001.3 | 3.903161 |
| 96 52 18.7 | 276 48 13.0 | Paradise Rock | 8663.3 | 3.937683 |
| 32 15 42.2 | 212 14 20.3 | East Rock. | 5377.9 | 3.730613 |
| 72 36 29.8 | 252 33 21.7 | Paradise Rock | 6897.9 | 3.838715 |
| 326 53 33.1 | 146 54 30.8 | Simmons 2. | 3696.0 | 3.567735 |
| 317 20 11 | 137 27 42 | Great Meadow | 22963.8 | 4.361044 |
| 229 58 58 | 50 10 40 | Blue Hill (Borden). | 31285.6 | 4.495344 |
| 19 20 33 | 199 13 48 | McSparran | 42668.3 | 4.630105 |
| 354 56 55 | 174 58 13 | Quaker. | 30816.3 | 4.488780 |
| 130 32 00 | 310 26 51 | College Hill | 14066.5 | 4.148187 |
| 198 13 55 | 18 16 05 | Great Meadow. | 14369.1 | 4.157430 |

**MASSACHUSETTS AND RHODE ISLAND BOUNDARY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Burnt Swamp (Borden). | 42 01 08.36 | 257.9 | 71 22 54.53 | 1254.6 |
| Bald Hill (Borden). | 42 02 44.22 | 1364.3 | 71 42 35.59 | 818.4 |
| Alumpond (Borden). | 42 01 14.51 | 447.7 | 71 45 45.24 | 1040.8 |
| Mount Daniel (Borden). | 42 01 41.54 | 1281.6 | 71 48 10.30 | 236.9 |
| Northwest corner of Rhode Island (Borden). | 42 00 29.15 | 899.4 | 71 47 58.92 | 1355.8 |
| Northeast corner of Connecticut (Borden). | 42 01 24.82 | 765.8 | 71 48 04.20 | 96.6 |
| Water tower. | 41 59 46.52 | 1435.3 | 71 19 21.66 | 498.5 |
| Hoppin Hill. | 41 57 52.71 | 1626.3 | 71 20 52.27 | 1203.6 |
| Foxboro' Baptist church, white spire. | 42 03 51.18 | 1579.1 | 71 15 05.06 | 116.3 |
| Foxboro' Orthodox church, dark spire. | 42 03 54.65 | 1686.1 | 71 15 08.34 | 191.7 |
| Norton, dark red spire. | 41 58 10.49 | 323.6 | 71 10 55.37 | 1274.9 |
| Lone fir tree. | 41 54 57.45 | 1772.5 | 71 13 43.32 | 998.3 |
| Attleboro' Catholic church. | 41 56 54.14 | 1670.4 | 71 17 22.60 | 520.5 |
| Verification south base (Borden). 1836. | 41 50 13.04 | 402.3 | 71 21 28.68 | 661.8 |
| Verification north base (Borden). 1836. | 41 54 25.94 | 800.3 | 71 21 20.68 | 476.6 |
| Quicksand 2. 1870. | 41 29 56.40 | 1740.0 | 71 07 09.16 | 212.4 |

**WORCESTER AND MIDDLESEX COUNTIES.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| Hasnebumskit (Borden). | 42 18 05.114 | 157.8 | 71 53 50.811 | 1163.8 |
| Fay's Mountain (Borden). | 42 14 23.786 | 733.9 | 71 37 42.540 | 975.3 |
| Mugget (Borden). | 42 08 02.120 | 65.4 | 71 57 26.236 | 602.6 |
| Watatick (Borden). | 42 41 48.553 | 1498.1 | 71 53 34.870 | 793.7 |
| Hatchet (Borden). | 42 01 39.60 | 1221.8 | 72 04 46.74 | 1075.2 |

**MASSACHUSETTS AND RHODE ISLAND BOUNDARY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 125 54 18 | 305 53 23 | Joe's Rock | 2348.4 | 3.370766 |
| 209 20 39 | 29 21 00 | Red Brush. | 1458.0 | 3.163751 |
| 151 27 14 | 331 19 40 | Hasnebumskit | 32365.1 | 4.510077 |
| 249 12 18 | 69 36 15 | Blue Hill (Borden). | 52578.1 | 4.720805 |
| 160 22 24 | 340 16 58 | Hasnebumskit | 33114.0 | 4.520011 |
| 274 40 34 | 94 53 18 | Beaconpole (Borden). | 26372.0 | 4.421144 |
| 284 01 11 | 104 02 48 | Alumpond | 3438.3 | 3.536350 |
| 89 56 35 | 269 45 28 | Hatchet. | 22921.2 | 4.360238 |
| 95 26 56 | 275 15 41 | Hatchet | 23288.5 | 4.367142 |
| 173 17 09 | 353 17 01 | Mount Daniel. | 2248.8 | 3.351960 |
| 164 50 30 | 344 50 26 | Mount Daniel | 534.4 | 2.72786 |
| 275 40 05 | 95 41 38 | Alumpond. | 3211.9 | 3.50676 |
| 326 03 18 | 146 07 32 | Great Meadow | 15665.3 | 4.19494 |
| 89 21 52 | 269 16 45 | Beaconpole. | 10578.7 | 4.02443 |
| 238 51 18 | 58 56 31 | Mansfield spire | 12586.4 | 4.09990 |
| 311 10 58 | 131 16 12 | Great Meadow. | 14398.9 | 4.15833 |
| 7 44 06 | 187 43 00 | Oak Hill | 16811.3 | 4.22560 |
| 69 37 30 | 249 32 36 | Red Brush. | 10757.7 | 4.03172 |
| 7 25 57 | 187 24 54 | Oak Hill | 16907.5 | 4.22808 |
| 68 56 54 | 248 52 02 | Red Brush. | 10725.3 | 4.03041 |
| 16 15 22 | 196 13 57 | Great Meadow | 10455.6 | 4.01935 |
| 52 32 16 | 232 28 24 | Oak Hill. | 10099.5 | 4.00430 |
| 346 57 11 | 166 57 38 | Great Meadow | 4190.3 | 3.62224 |
| 87 22 17 | 267 20 17 | Oak Hill. | 4150.5 | 3.61810 |
| 215 35 33 | 35 38 26 | Mansfield spire | 10220.7 | 4.00948 |
| 321 59 33 | 142 02 27 | Great Meadow. | 9747.2 | 3.98888 |
| 169 49 19 | 349 47 26 | Joe's Rock | 21942.1 | 4.34128 |
| 247 14 49 | 67 17 38 | Great Rock. | 6333.1 | 3.80161 |
| 313 25 31 | 133 28 14 | Great Rock | 7787.7 | 3.89141 |
| 1 21 22 | 181 21 17 | Verification south base. | 7804.4 | 3.89234 |
| 113 31 48 | 293 29 14 | Little Compton 2 | 5880.7 | 3.76943 |
| 77 28 34 | 257 26 58 | Simmons. | 3457.5 | 3.53876 |

**WORCESTER AND MIDDLESEX COUNTIES.**

| | | | | |
|---|---|---|---|---|
| 239 36 08.5 | 60 08 10.2 | Holt | 75169.6 | 4.876042 |
| 278 27 55.5 | 98 59 30.6 | Blue Hill (Borden). | 65353.2 | 4.815267 |
| 273 59 30.2 | 94 20 13.4 | Blue Hill (Borden) | 42534.6 | 4.628742 |
| 330 14 03.6 | 150 21 25.8 | Beaconpole (Borden). | 30567.4 | 4.485258 |
| 188 18 25.2 | 8 21 15.0 | Wachusett | 39873.9 | 4.600688 |
| 194 51 10.2 | 14 53 35.0 | Hasnebumskit. | 19250.0 | 4.284430 |
| 358 48 56.7 | 178 49 10.8 | Wachusett | 23078.5 | 4.363207 |
| 275 13 04.5 | 95 45 02.6 | Holt. | 64741.2 | 4.811181 |
| 206 17 02 | 26 24 22 | Hasnebumskit | 33931.2 | 4.530600 |
| 271 34 57 | 91 47 41 | Alumpond. | 26272.3 | 4.419498 |

**WORCESTER AND MIDDLESEX COUNTIES**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Chandler's Hill (Borden). | 42 16 15.20 | 469.0 | 71 47 11.43 | 261.9 |
| Tuft's Hill (Borden). | 42 19 01.54 | 47.5 | 72 05 04.56 | 104.4 |
| Hawe's Hill (Borden). | 42 27 26.43 | 815.6 | 72 07 07.17 | 163.8 |
| Pepperell (Borden). | 42 42 12.64 | 390.0 | 71 35 12.59 | 286.5 |
| Watatick State line (Borden). | 42 42 40.93 | 1263.0 | 71 53 55.73 | 1268.2 |

**MASSACHUSETTS, NEW YORK, AND CONNECTICUT BOUNDARY.**

| | | | | |
|---|---|---|---|---|
| Saddle Mountain (Borden). | 42 38 14.125 | 435.8 | 73 09 58.908 | 1342.1 |
| Becket (Borden). | 42 18 06.712 | 207.1 | 73 08 46.817 | 1072.3 |
| Alander Mountain (Borden), New York. | 42 05 15.057 | 464.6 | 73 30 18.725 | 430.4 |
| Seymore's Hill (Borden), | 42 03 27.856 | 859.5 | 73 06 14.729 | 338.7 |
| Jackson's Hill (Borden). | 42 10 20.198 | 623.2 | 73 00 50.109 | 1150.1 |
| Spruce Hill (Borden). | 42 40 12.597 | 388.7 | 73 04 09.889 | 225.2 |
| Berlin Mountain (Borden), New York. | 42 41 31.596 | 974.9 | 73 17 10.504 | 239.1 |
| Clarksburg (Borden). | 42 44 03.571 | 110.2 | 73 09 33.739 | 767.5 |
| Haines, New York. | 41 54 37.741 | 1164.5 | 73 34 08.072 | 186.0 |
| Prospect Hill, Connecticut. | 41 58 45.109 | 1391.8 | 73 23 06.278 | 144.5 |
| Northwest corner of Massachusetts (Borden). | 42 44 45.25 | 1396.3 | 73 15 54.17 | 1232.1 |
| Williamstown Congregational church (Borden).* | 42 42 48.76 | 1504.6 | 73 12 36.94 | 840.6 |
| Washington spire. | 42 21 57.78 | 1782.7 | 73 08 39.78 | 910.2 |
| Connecticut line (Borden). | 42 02 58.78 | 1813.6 | 73 29 42.92 | 986.9 |
| Southwest corner of Massachusetts (Borden). | 42 02 59.61 | 1839.2 | 73 31 18.72 | 430.4 |
| Brace Mountain monument, New York. | 42 02 39.91 | 1231.4 | 73 29 34.88 | 802.4 |

* Modern position different.

**WORCESTER AND MIDDLESEX COUNTIES**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 284 42 59 | 104 49 22 | Fay's Mountain | 13485.4 | 4.129863 |
| 42 53 31 | 222 46 38 | Mugget. | 20745.5 | 4.316924 |
| 220 18 51 | 40 26 50 | Wachusett' | 25082.6 | 4.399372 |
| 276 22 23 | 96 29 56 | Hasnebumskit. | 15528.8 | 4.191138 |
| 91 22 49 | 271 13 19 | Packard | 19287.6 | 4.285278 |
| 143 15 31 | 323 05 53 | Mount Grace. | 32483.4 | 4.511662 |
| 46 05 29 | 225 53 17 | Wachusett | 34279.5 | 4.535034 |
| 88 24 23 | 268 11 56 | Watatick. | 25099.7 | 4.399669 |
| 271 51 06 | 92 03 48 | Pepperell | 25575.5 | 4.407824 |
| 92 13 32 | 271 56 22 | Warwick. | 34576.3 | 4.538778 |

**MASSACHUSETTS, NEW YORK, AND CONNECTICUT BOUNDARY.**

| | | | | |
|---|---|---|---|---|
| 244 23 09.6 | 64 34 50.2 | Jilson | 26068.6 | 4.416117 |
| 301 16 03.2 | 121 31 33.9 | More's Hill. | 36786.1 | 4.565684 |
| 124 33 50.2 | 304 24 22.9 | Perry's Peak | 23375.2 | 4.368755 |
| 212 37 01.2 | 32 41 24.2 | French's Hill. | 16555.7 | 4.218949 |
| 254 51 24.0 | 74 54 18.0 | Bald Peak | 6180.0 | 3.790991 |
| 231 06 28.0 | 51 20 55.7 | Becket. | 38019.9 | 4.580011 |
| 100 21 11.6 | 280 07 57.9 | Bald Peak | 27665.0 | 4.441930 |
| 172 40 46.2 | 352 39 04.1 | Becket. | 27340.2 | 4.436801 |
| 77 27 05.2 | 257 10 12.8 | Bald Peak | 35522.1 | 4.550499 |
| 142 49 56.9 | 322 44 36.5 | Becket. | 18073.9 | 4.257051 |
| 354 30 28.6 | 174 31 45.3 | French's Hill | 27096.2 | 4.432908 |
| 65 20 16.3 | 245 16 19.8 | Saddle Mountain (Borden). | 8750.1 | 3.942012 |
| 277 44 10.6 | 97 52 59.8 | Spruce Hill | 17939.2 | 4.253802 |
| 301 45 19.7 | 121 50 12.2 | Saddle Mountain (Borden). | 11564.5 | 4.063128 |
| 314 00 24.4 | 134 04 04.0 | Spruce Hill | 10253.1 | 4.010854 |
| 3 02 39.1 | 183 02 22.0 | Saddle Mountain (Borden). | 10798.1 | 4.033346 |
| 278 25 49.1 | 98 39 37.2 | Ivy | 28911.1 | 4.461065 |
| 207 49 42.6 | 27 55 09.8 | Bald Hill. | 24067.6 | 4.381432 |
| 311 46 39.1 | 131 53 05.5 | Ivy | 17884.7 | 4.252482 |
| 63 27 59.2 | 243 20 36.9 | Haines. | 17047.9 | 4.231672 |
| 278 25 05 | 98 29 23 | Clarksburg | 8748.3 | 3.941924 |
| 326 08 30 | 146 12 31 | Saddle Mountain (Borden). | 14527.9 | 4.162204 |
| 292 36 43 | 112 42 27 | Spruce Hill | 12507.8 | 4.097180 |
| 69 05 53 | 249 02 48 | Berlin Mountain. | 6666.1 | 3.823870 |
| 107 31 58 | 287 22 25 | Perry's Peak | 20355.8 | 4.308689 |
| 176 33 56 | 356 33 03 | Greylock. | 30179.4 | 4.479710 |
| 168 55 36 | 348 55 12 | Alander Mountain | 4284.5 | 3.63190 |
| 221 28 19 | 41 30 49 | Bald Peak. | 7765.5 | 3.89017 |
| 198 15 36 | 18 16 16 | Alander Mountain | 4401.0 | 3.64355 |
| 270 39 05 | 90 40 09 | Connecticut Line. | 2203.3 | 3.34308 |
| 308 58 39 | 129 02 59 | Prospect Hill | 11508.2 | 4.061009 |
| 22 56 37 | 202 53 35 | Haines. | 16151.5 | 4.208214 |

**MASSACHUSETTS, NEW YORK, AND CONNECTICUT BOUNDARY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Iron Bolt. | 42 02 58.67 | 1810.2 | 73 29 42.62 | 980.1 |
| Ryant Bush. | 42 03 04.05 | 125.0 | 73 28 56.63 | 1302.3 |
| Ball Peak (or Mount Riga), Connecticut. | 42 00 43.33 | 1336.9 | 73 27 57.84 | 1330.8 |
| Corner Stone, New York. | 42 02 58.38 | 1801.2 | 73 29 15.96 | 367.0 |
| Pittsfield First Congregational church. | 42 26 56.1 | 1731.1 | 73 15 09.6 | 219.3 |

**CONNECTICUT RIVER VALLEY.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| Mount Grace (Borden). | 42 41 29.137 | 899.1 | 72 21 20.803 | 473.5 |
| Packard (C. & G. S. & Borden). | 42 27 40.636 | 1253.9 | 72 21 11.087 | 253.3 |
| More's Hill (Borden). | 42 27 53.041 | 1636.7 | 72 47 02.631 | 60.1 |
| Jilson (Borden). | 42 44 18.050 | 556.9 | 72 52 45.496 | 1034.8 |
| Colonel's Mountain (Borden). | 42 14 09.353 | 288.6 | 72 13 58.354 | 1338.0 |
| Hilliard's Knob (C. & G. S. & Borden). | 42 18 20.230 | 624.3 | 72 30 38.374 | 878.8 |
| Mount Lincoln (C. & G. S. & Borden). | 42 21 49.379 | 1523.6 | 72 25 24.533 | 561.4 |
| Proven's Mountain (C. & G. S. & Borden). | 42 05 04.486 | 138.4 | 72 42 17.176 | 394.8 |
| Hitchcock (Borden). | 42 05 07.392 | 228.1 | 72 15 35.428 | 814.2 |
| Dug Hill (Borden). | 42 12 25.341 | 781.8 | 72 56 27.159 | 623.0 |
| Winchell's Mountain (Borden). | 42 03 29.137 | 899.0 | 72 54 08.006 | 184.1 |
| Peaked Mountain (C. & G. S. & Borden). | 42 02 50.935 | 1571.5 | 72 20 26.198 | 602.5 |
| High Ridge (C. & G. S. & Borden). | 42 26 55.123 | 1700.9 | 72 43 06.613 | 151.1 |
| Mount Esther (C. & G. S. & Borden). | 42 27 10.190 | 314.4 | 72 39 54.642 | 1248.5 |
| Hatfield North Base (C. & G. S. & Borden). 1832. | 42 28 46.150 | 1424.0 | 72 36 43.569 | 995.2 |
| Hatfield South Base (Borden). 1832. | 42 22 20.843 | 643.2 | 72 36 50.973 | 1166.2 |

MASSACHUSETTS, NEW YORK, AND CONNECTICUT BOUNDARY—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 310 35 10 | 130 39 35 | Prospect Hill | 12015.5 | 4.079741 |
| 21 35 58 | 201 33 00 | Haines. | 16619.8 | 4.220626 |
| 314 42 34 | 134 46 28 | Prospect Hill | 11349.8 | 4.054989 |
| 24 41 02 | 204 37 34 | Haines. | 17188.3 | 4.235233 |
| 298 29 53 | 118 33 08 | Prospect Hill | 7637.8 | 3.882970 |
| 37 07 10 | 217 03 03 | Haines. | 14139.4 | 4.150430 |
| 37 22 17 | 217 22 04 | Brace Mountain Monument | 717.0 | 2.855553 |
| 336 39 53 | 156 40 45 | Ball Peak. | 4537.5 | 3.656682 |
| 73 35.4 | 253 30.2 | Perry's Peak | 10944. | 4.03916 |
| 198 41.5 | 18 45.0 | Saddle Mountain. | 22090. | 4.34419 |

CONNECTICUT RIVER VALLEY.

| | | | | |
|---|---|---|---|---|
| 300 08 27.7 | 120 27 29.3 | Wachusett | 44545.8 | 4.648807 |
| 268 56 16.8 | 89 15 06.4 | Watatick. | 37926.2 | 4.578939 |
| 265 13 52.2 | 85 32 44.7 | Wachusett | 38434.0 | 4.584715 |
| 179 30 15.6 | 359 30 09.0 | Mount Grace. | 25565.5 | 4.407654 |
| 270 28 23.4 | 90 45 50.9 | Packard | 35450.4 | 4.549622 |
| 234 14 46.6 | 54 32 09.8 | Mount Grace. | 43248.9 | 4.635975 |
| 276 45 06.5 | 97 06 24.9 | Mount Grace | 43202.4 | 4.635508 |
| 345 32 45.2 | 165 36 37.3 | More's Hill. | 31382.9 | 4.496693 |
| 225 14 28.7 | 45 28 27.2 | Wachusett | 40021.7 | 4.602295 |
| 255 09 35.0 | 75 23 07.2 | Hasnebumskit. | 28614.2 | 4.456582 |
| 196 29 36.4 | 16 35 53.0 | Mount Grace | 44707.3 | 4.650378 |
| 128 13 25.3 | 308 02 21.8 | More's Hill. | 28623.7 | 4.456726 |
| 48 06 01.3 | 228 02 29.9 | Hilliard's Knob | 9657.6 | 3.984869 |
| 110 49 51.4 | 290 35 15.8 | More's Hill. | 31731.1 | 4.501485 |
| 213 04 51.1 | 33 12 40.8 | Hilliard's Knob | 29323.7 | 4.467219 |
| 171 13 15.3 | 351 10 03.3 | More's Hill. | 42730.1 | 4.630734 |
| 156 26 58.0 | 336 20 22.1 | Mount Lincoln | 33739.0 | 4.528132 |
| 187 34 55.3 | 7 36 00.5 | Colonel's Mountain. | 16869.6 | 4.227104 |
| 252 32 49.3 | 73 00 10.8 | Hilliard's Knob | 37151.7 | 4.569979 |
| 204 14 47.2 | 24 21 07.4 | More's Hill. | 31406.6 | 4.497021 |
| 259 43 42.1 | 79 51 38.4 | Proven's Mountain | 16604.0 | 4.220212 |
| 169 04 46.2 | 349 03 12.8 | Dug Hill. | 16849.9 | 4.226597 |
| 130 24 12.0 | 310 11 48.1 | Mount Tom | 33385.7 | 4.523560 |
| 153 57 05.2 | 333 50 14.2 | Hilliard's Knob. | 31930.0 | 4.504199 |
| 345 54 04.9 | 165 56 54.3 | Mount Tom | 23677.1 | 4.374328 |
| 312 47 36.5 | 132 56 00.8 | Hilliard's Knob. | 23354.8 | 4.368375 |
| 296 22 08.9 | 116 31 55.7 | Mount Lincoln | 22223.2 | 4.346806 |
| 322 03 21.5 | 142 09 36.4 | Hilliard's Knob. | 20720.6 | 4.316403 |
| 309 34 24.2 | 129 42 02.3 | Mount Lincoln | 20158.7 | 4.304463 |
| 336 34 37.0 | 156 38 43.2 | Hilliard's Knob. | 21042.0 | 4.323086 |
| 273 28 21.7 | 93 36 04.3 | Mount Lincoln | 15736.8 | 4.196918 |
| 180 48 53.9 | 0 48 58.9 | Hatfield North Base. | 11890.1 | 4.075184 |

**CONNECTICUT RIVER VALLEY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Rock Rimmon. | 42 14 23.142 | 714.0 | 72 26 29.066 | 666.4 |
| Facing Rock. | 42 13 08.840 | 272.8 | 72 27 34.996 | 802.7 |
| Feeding Hills. | 42 03 52.203 | 1610.7 | 72 40 53.754 | 1235.9 |
| McCarthy. | 42 04 13.049 | 402.6 | 72 30 17.177 | 394.9 |
| Brush. | 42 09 03.891 | 120.1 | 72 39 39.619 | 909.7 |
| Crafts. | 42 12 46.510 | 1435.1 | 72 38 20.460 | 469.3 |
| Shingle Hill. | 42 23 23.355 | 720.6 | 72 41 59.471 | 1360.3 |
| Mount Warner. | 42 22 48.389 | 1493.1 | 72 34 22.124 | 506.1 |
| North Warner. | 42 22 55.991 | 1727.6 | 72 34 17.930 | 410.2 |
| Amherst College chapel. | 42 22 15.291 | 471.8 | 72 31 06.965 | 159.4 |
| Dickinson. | 42 25 31.485 | 971.5 | 72 30 26.662 | 609.5 |
| Mount Tom (Borden). | 42 14 30.80 | 950.3 | 72 38 55.12 | 1263.7 |
| Walnut Hill (Borden). | 42 39 06.03 | 186.1 | 72 46 29.42 | 670.2 |
| Bear Mount (Borden). | 42 35 13.62 | 420.3 | 72 25 32.89 | 749.9 |
| Warwick (Borden). | 42 43 21.57 | 665.6 | 72 19 14.26 | 324.4 |
| Leyden and Guilford (Borden). | 42 43 55.29 | 1706.1 | 72 38 24.79 | 563.9 |
| Rattlesnake (Borden). | 42 01 59.59 | 1838.6 | 72 24 28.62 | 658.4 |
| Secondary signal (Borden). | 42 02 23.04 | 710.8 | 72 54 07.82 | 179.9 |
| Boundary Rock (Borden). | 42 01 53.84 | 1661.1 | 72 16 18.42 | 423.8 |
| Connecticut line signal (Borden). | 42 01 55.98 | 1727.2 | 72 20 46.14 | 1061.4 |
| Rattle, flag in tree. | 42 01 59.08 | 1822.8 | 72 24 28.67 | 659.5 |
| Wigwam. | 42 06 26.00 | 802.2 | 72 24 45.10 | 1036.2 |
| Dumpling. | 42 10 24.46 | 754.7 | 72 20 27.90 | 640.4 |

**CONNECTICUT RIVER VALLEY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 338 39 11.1 | 158 43 14.6 | Peaked Mountain | 22925.3 | 4.360315 |
| 90 51 39.2 | 270 43 17.7 | Mount Tom. | 17105.5 | 4.233136 |
| 332 38 27.8 | 152 43 15.5 | Peaked Mountain | 21458.1 | 4.331592 |
| 99 16 27.0 | 279 08 49.9 | Mount Tom. | 15798.5 | 4.198615 |
| 273 43 01.4 | 93 56 43.7 | Peaked Mountain | 28290.3 | 4.451638 |
| 187 51 49.5 | 7 53 09.2 | Mount Tom. | 19890.9 | 4.298654 |
| 280 30 22.1 | 100 36 58.0 | Peaked Mountain | 13822.8 | 4.140597 |
| 148 05 32.5 | 327 59 44.9 | Mount Tom. | 22464.4 | 4.351496 |
| 293 21 39.7 | 113 34 33.0 | Peaked Mountain | 28894.5 | 4.460816 |
| 241 25 18.5 | 61 34 09.5 | Rock Rimmon. | 20640.6 | 4.314723 |
| 306 34 38.0 | 126 46 38.6 | Peaked Mountain | 30764.4 | 4.488048 |
| 259 34 36.4 | 79 42 34.5 | Rock Rimmon. | 16584.6 | 4.219705 |
| 300 53 52.0 | 121 01 30.8 | Hilliard's Knob | 18180.1 | 4.259595 |
| 345 34 08.7 | 165 36 12.9 | Mount Tom. | 16966.1 | 4.229581 |
| 95 55 49.6 | 275 50 41.3 | Shingle Hill | 10517.5 | 4.021914 |
| 22 10 42.2 | 202 07 38.5 | Mount Tom. | 16576.9 | 4.219502 |
| 94 36 55.7 | 274 31 44.6 | Shingle Hill | 10591.5 | 4.024958 |
| 22 10 48.9 | 202 07 42.3 | Mount Tom. | 16830.3 | 4.226091 |
| 354 50 26.6 | 174 50 45.9 | Hilliard's Knob | 7282.3 | 3.862266 |
| 98 04 10.4 | 277 56 50.6 | Shingle Hill. | 15074.5 | 4.178243 |
| 1 09 17.8 | 181 09 09.9 | Hilliard's Knob | 13309.2 | 4.124152 |
| 98 31 19.2 | 278 22 46.4 | High Ridge. | 17560.6 | 4.244539 |
| 273 43 13 | 93 43 13 | Mount Tom | 1519.5 | 0.18170 |
| | | | | |
| 2 05 27 | 182 05 02 | More's Hill | 20779.0 | 4.317624 |
| 262 31 58 | 82 48 58 | Mount Grace. | 34637.2 | 4.539543 |
| 336 49 36 | 156 52 33 | Packard | 15201.1 | 4.181875 |
| 65 20 01 | 245 05 29 | More's Hill. | 32424.9 | 4.510879 |
| 39 42 05 | 219 40 39 | Mount Grace | 4508.2 | 3.654000 |
| 305 57 45 | 126 15 21 | Wachusett. | 44023.0 | 4.643680 |
| 280 51 30 | 101 03 04 | Mount Grace | 23734.9 | 4.375388 |
| 312 24 16 | 132 32 59 | Bear Mountain. | 23836.5 | 4.377242 |
| 103 10 15 | 282 58 19 | Proven's Mountain | 25223.4 | 4.401804 |
| 164 21 55 | 344 17 47 | Hilliard's Knob. | 31424.6 | 4.497269 |
| 170 14 25 | 350 12 52 | Dug Hill | 18857.3 | 4.275479 |
| 252 58 43 | 73 06 39 | Proven's Mountain. | 17082.3 | 4.232546 |
| 107 12 20 | 287 09 34 | Peaked Mountain | 5965.5 | 3.775644 |
| 189 23 30 | 9 23 59 | Hitchcock. | 6053.7 | 3.782023 |
| 230 23 30 | 50 26 58 | Hitchcock | 9269.4 | 3.967053 |
| 270 35 55 | 90 38 54 | Boundary Rock. | 6158.9 | 3.789505 |
| 117 19 00 | 297 15 07 | McCarthy | 9017.4 | 3.95508 |
| 153 58 09 | 74 00 52 | Peaked Mountain. | 5801.6 | 3.76355 |
| 170 48 09 | 350 46 59 | Rock Rimmon | 14913.9 | 4.17359 |
| 318 05 16 | 138 08 09 | Peaked Mountain. | 8913.3 | 3.95004 |
| 131 40 01 | 311 35 58 | Rock Rimmon | 11085.1 | 4.04474 |
| 359 50 24 | 179 50 25 | Peaked Mountain. | 13992.7 | 4.14590 |

**CONNECTICUT RIVER VALLEY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Fish Rock. | 42 10 35.96 | 1109.5 | 72 47 57.78 | 1326.1 |
| White, flag in tree. | 42 12 02.27 | 70.0 | 72 29 47.53 | 1090.5 |
| Longmeadow, Congregational church spire. | 42 03 00.83 | 25.6 | 72 34 56.24 | 1293.3 |
| East Longmeadow, Congregational church spire. | 42 03 51.49 | 1588.7 | 72 30 45.62 | 1048.9 |
| Feeding Hills, Congregational church spire. | 42 04 04.15 | 128.0 | 72 40 45.48 | 1045.6 |
| Feeding Hills, Methodist church spire. | 42 03 58.94 | 1818.5 | 72 40 44.54 | 1024.0 |
| Holland's (H.) house, chimney. | 42 05 05.04 | 155.5 | 72 42 14.89 | 342.2 |
| Springfield, water-shops tower. | 42 05 51.94 | 1602.6 | 72 33 50.44 | 1159.1 |
| Springfield, Florence street Methodist church spire. | 42 06 01.11 | 34.2 | 72 34 03.72 | 85.5 |
| Springfield, Hope Congregational church tower. | 42 06 38.69 | 1193.8 | 72 33 55.63 | 1278.1 |
| Springfield, State street Methodist church. | 42 06 19.18 | 591.8 | 72 34 53.36 | 1226.1 |
| Springfield Arsenal, clock tower. | 42 06 26.48 | 817.0 | 72 34 54.70 | 1256.8 |
| Springfield, South Congregational church tower. | 42 06 08.04 | 248.1 | 72 35 00.10 | 2.3 |
| Springfield, First Baptist church spire. | 42 06 10.88 | 335.7 | 72 35 04.19 | 96.3 |
| Springfield, North Congregational church spire. | 42 06 21.77 | 671.7 | 72 35 13.45 | 309.0 |
| Springfield, court-house, tower. | 42 06 01.48 | 45.7 | 22 35 21.02 | 483.0 |
| Springfield, Saint Michael's church spire. | 42 06 15.20 | 469.0 | 72 35 05.10 | 117.2 |
| Springfield, Saint Joseph's Catholic church spire. | 42 06 06.63 | 204.6 | 72 35 10.64 | 244.5 |
| West Springfield, Park street Congregational church spire. | 42 06 23.52 | 725.7 | 73 37 11.54 | 265.1 |
| West Springfield, First Congregational church spire. | 42 06 52.18 | 1610.0 | 72 37 31.94 | 733.8 |
| Chicopee, Catholic church spire. | 42 08 40.26 | 1242.2 | 72 36 20.25 | 465.0 |
| Chicopee, town hall spire. | 42 08 54.65 | 1686.2 | 72 36 25.94 | 595.6 |
| Chicopee, French Catholic church spire. | 42 08 49.11 | 1515.2 | 72 35 34.15 | 784.1 |

**CONNECTICUT RIVER VALLEY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 239 44 56 | 59 51 01 | Mount Tom | 14404.6 | 4.15850 |
| 295 46 19 | 115 58 11 | McCarthy. | 27075.7 | 4.43258 |
| 110 06 02 | 289 59 55 | Mount Tom | 13367.5 | 4.12605 |
| 235 56 32 | 55 58 01 | Facing Rock. | 3668.6 | 3.56450 |
| 208 20 08 | 28 25 04 | Facing Rock | 21322.6 | 4.32884 |
| 250 49 33 | 70 52 40 | McCarthy. | 6791.9 | 3.83199 |
| 90 08 46 | 270 01 59 | Feeding Hills | 13981.7 | 4.14556 |
| 150 22 34 | 330 17 06 | Mount Tom. | 22702.3 | 4.35607 |
| 27 18 57 | 207 18 51 | Feeding Hills | 414.9 | 2.61793 |
| 268 51 09 | 88 58 10 | McCarthy. | 14447.1 | 4.15978 |
| 45 33 07 | 225 33 01 | Feeding Hills | 297.0 | 2.47277 |
| 268 12 47 | 88 19 48 | McCarthy. | 14429.8 | 4.15926 |
| 205 48 47 | 25 50 31 | Brush | 8187.3 | 3.91314 |
| 320 18 16 | 140 19 10 | Feeding Hills. | 2920.6 | 3.46547 |
| 69 14 56 | 249 10 12 | Feeding Hills | 10407.8 | 4.01736 |
| 126 28 31 | 306 24 37 | Brush. | 9970.3 | 3.99871 |
| 67 09 25 | 247 04 50 | Feeding Hills | 10229.4 | 4.00985 |
| 126 11 46 | 306 08 01 | Brush. | 9556.7 | 3.98031 |
| 311 48 34 | 131 51 00 | McCarthy | 6738.0 | 3.82853 |
| 61 54 44 | 241 50 04 | Feeding Hills. | 10896.8 | 4.03730 |
| 301 29 11 | 121 32 16 | McCarthy | 7445.8 | 3.87191 |
| 61 20 01 | 241 15 59 | Feeding Hills. | 9443.4 | 3.97513 |
| 126 36 16 | 306 33 05 | Brush | 8149.3 | 3.91112 |
| 159 45 30 | 339 42 49 | Mount Tom. | 15928.9 | 4.20219 |
| 298 35 34 | 118 38 42 | McCarthy | 7407.5 | 3.86967 |
| 62 45 25 | 242 41 28 | Feeding Hills. | 9145.8 | 3.96122 |
| 61 59 46 | 241 55 52 | Feeding Hills | 9102.9 | 3.95918 |
| 130 10 57 | 310 07 53 | Brush. | 8277.7 | 3.91791 |
| 59 29 28 | 239 25 40 | Feeding Hills | 9081.6 | 3.95816 |
| 160 08 06 | 340 06 00 | Crafts. | 12623.5 | 4.10118 |
| 62 29 05 | 242 25 22 | Feeding Hills | 8625.8 | 3.93580 |
| 161 46 20 | 341 44 19 | Crafts. | 13158.3 | 4.1.920 |
| 61 11 42 | 241 07 49 | Feeding Hills | 9148.1 | 3.96133 |
| 129 33 38 | 309 40 34 | Brush. | 8175.8 | 3.91253 |
| 297 25 40 | 117 28 57 | McCarthy | 7601.0 | 3.88087 |
| 62 17 27 | 242 13 37 | Feeding Hills. | 8910.7 | 3.94991 |
| 171 01 46 | 351 00 36 | Mount Tom | 15221.2 | 4.18245 |
| 172 22 48 | 352 22 02 | Crafts. | 11922.3 | 4.07636 |
| 39 53 23 | 219 51 08 | Feeding Hills | 7235.2 | 3.85945 |
| 144 11 52 | 324 10 26 | Brush. | 5011.3 | 3.69995 |
| 99 04 06 | 279 01 52 | Brush | 4635.5 | 3.66610 |
| 235 26 36 | 55 32 28 | Facing Rock. | 14627.8 | 4.16518 |
| 33 25 33 | 213 22 34 | Feeding Hills | 11177.9 | 4.04836 |
| 93 41 04 | 273 38 54 | Brush. | 4456.4 | 3.64898 |
| 94 38 54 | 274 36 09 | Brush | 5654.7 | 3.75241 |
| 152 29 31 | 332 27 40 | Crafts. | 8259.6 | 3.91696 |

**CONNECTICUT RIVER VALLEY—Continued.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Chicopee, skating rink spire. | 42 08 50.25 | 1550.4 | 72 36 36.77 | 844.3 |
| Chicopee Falls, Catholic church spire. | 42 09 42.82 | 1321.2 | 72 34 51.06 | 1172.2 |
| Chicopee Falls, Congregational church spire. | 42 09 25.06 | 773.2 | 72 34 51.70 | 1186.9 |
| Chicopee Falls, New Baptist church spire. | 42 09 26.08 | 804.7 | 72 34 54.10 | 1242.0 |
| Chicopee Falls, Methodist church spire. | 42 09 25.50 | 786.8 | 72 35 00.37 | 8.5 |
| Holyoke, St. Jerome's Catholic church spire. | 42 12 34.10 | 1052.1 | 72 36 31.76 | 728.6 |
| Holyoke, Second Congregational church tower. | 42 12 18.36 | 566.5 | 72 36 39.50 | 906.2 |
| Holyoke, Second Baptist church tower. | 42 12 24.78 | 764.6 | 72 36 48.58 | 1114.4 |
| Holyoke, French Catholic church spire. | 42 11 56.88 | 1755.0 | 72 36 23.26 | 533.7 |
| Holyoke, engine-house tower. | 42 12 46.50 | 1434.7 | 72 37 31.98 | 733.6 |
| Holyoke, First Congregational church belfry. | 42 12 41.16 | 1270.0 | 72 37 49.36 | 1132.3 |
| Holyoke, Windsor Hotel tower. | 42 12 23.07 | 711.8 | 72 36 22.72 | 521.2 |
| Holyoke, city hall tower. | 42 12 24.32 | 750.4 | 72 36 28.10 | 644.6 |
| Baptistville, First Baptist church spire. | 42 11 42.04 | 1297.1 | 72 37 49.05 | 1125.4 |
| East Bench Mark. | 42 12 53.96 | 1664.9 | 72 36 10.22 | 234.4 |
| East Tidal Bench Mark. | 42 12 53.95 | 1664.6 | 72 36 10.40 | 238.5 |
| West Bench Mark. | 42 12 44.22 | 1364.4 | 72 36 14.10 | 323.4 |
| South Hadley Falls, Catholic church spire. | 42 13 13.03 | 402.0 | 72 36 05.58 | 128.0 |
| South Hadley Falls, Methodist church spire. | 42 13 00.92 | 28.4 | 72 35 56.42 | 1294.1 |
| South Hadley Falls, Congregational church spire. | 42 12 58.25 | 1797.2 | 72 35 56.56 | 1297.3 |
| South Hadley Female Seminary observatory. | 42 15 21.78 | 672.0 | 72 34 40.88 | 937.1 |
| South Hadley, Congregational church spire. | 42 15 31.59 | 974.7 | 72 34 31.26 | 716.5 |
| Wilbraham, Rich Hall tower. | 42 07 27.68 | 854.0 | 72 25 55.10 | 1265.6 |

CONNECTICUT RIVER VALLEY—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 95 44 26 | 275 42 23 | Brush | 4219.4 | 3.62525 |
| 161 55 45 | 341 54 36 | Crafts. | 7668.3 | 3.88470 |
| 79 44 58 | 259 41 44 | Brush | 6732.9 | 3.82820 |
| 139 43 38 | 319 41 17 | Crafts. | 7430.4 | 3.87101 |
| 84 23 08 | 264 19 55 | Brush | 6642.6 | 3.82234 |
| 142 23 44 | 322 21 24 | Crafts. | 7847.8 | 3.89475 |
| 142 34 33 | 322 32 14 | Crafts | 7789.1 | 3.89149 |
| 235 39 35 | 55 44 30 | Facing Rock. | 22197.2 | 4.08626 |
| 143 30 17 | 323 28 03 | Crafts | 7716.8 | 3.88744 |
| 235 58 02 | 56 03 01 | Facing Rock. | 12326.2 | 4.09083 |
| 98 44 06 | 278 42 53 | Crafts | 2522.7 | 3.40186 |
| 137 37 29 | 317 35 53 | Mount Tom. | 4875.3 | 3.68800 |
| 110 33 59 | 290 32 51 | Crafts | 2473.4 | 3.39329 |
| 142 44 57 | 322 43 26 | Mount Tom. | 5135.1 | 3.71055 |
| 107 38 49 | 287 37 47 | Crafts | 2211.6 | 3.34471 |
| 143 17 13 | 323 15 48 | Mount Tom. | 4851.2 | 3.68585 |
| 119 40 28 | 299 39 09 | Crafts | 3094.0 | 3.49052 |
| 143 46 12 | 323 44 30 | Mount Tom. | 5889.0 | 3.77004 |
| 90 01 30 | 270 00 57 | Crafts | 1112.1 | 3.04616 |
| 149 22 51 | 329 21 55 | Mount Tom. | 3740.3 | 3.57291 |
| 103 01 32 | 283 01 11 | Crafts | 732.3 | 2.86470 |
| 155 59 52 | 335 59 08 | Mount Tom. | 3703.4 | 3.56860 |
| 254 43 22 | 74 50 01 | Rock Rimmon | 14109.8 | 4.14952 |
| 263 17 50 | 83 23 44 | Facing Rock. | 12186.8 | 4.08589 |
| 104 52 52 | 284 51 37 | Crafts | 2666.9 | 3.42600 |
| 139 11 47 | 319 10 08 | Mount Tom. | 5156.6 | 3.71236 |
| 160 05 32 | 340 05 11 | Crafts | 2115.8 | 3.32548 |
| 259 10 44 | 79 17 36 | Facing Rock. | 14338.7 | 4.15651 |
| 24 09 27 | 204 09 15 | Holyoke City Hall | 1002.3 | 3.00098 |
| 128 20 16 | 308 18 25 | Mount Tom. | 4818.8 | 3.68294 |
| 85 36 52 | 265 35 25 | Crafts | 2992.1 | 3.47597 |
| 128 22 27 | 308 20 36 | Mount Tom. | 4815.4 | 3.68263 |
| 131 42 45 | 311 40 57 | Mount Tom | 4943.7 | 3.69405 |
| 196 32 57 | 16 33 00 | East Bench Mark. | 313.5 | 2.49621 |
| 75 12 24 | 255 10 53 | Crafts | 3200.7 | 3.50525 |
| 121 42 23 | 301 40 29 | Mount Tom. | 4567.1 | 3.65964 |
| 82 21 08 | 262 19 31 | Crafts | 3333.7 | 3.52293 |
| 124 06 50 | 304 04 50 | Mount Tom. | 4947.0 | 3.69434 |
| 83 45 06 | 263 43 29 | Crafts | 3220.5 | 3.52121 |
| 124 55 03 | 304 53 03 | Mount Tom. | 4991.0 | 3.69819 |
| 46 26 38 | 226 24 11 | Crafts | 6949.8 | 3.84197 |
| 74 55 02 | 254 52 11 | Mount Tom. | 6035.6 | 3.78072 |
| 45 55 11 | 225 52 37 | Crafts | 7319.0 | 3.86445 |
| 72 47 38 | 252 44 41 | Mount Tom. | 6331.7 | 3.80152 |
| 45 06 14 | 225 03 19 | McCarthy | 8504.7 | 3.92966 |
| 98 59 09 | 278 49 57 | Brush. | 19166.8 | 4.28255 |

**CONNECTICUT RIVER VALLEY—Continued.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Wilbraham, Congregational church spire. | 42 07 16.48 | 508.5 | 72 25 54.87 | 1260.4 |
| Indian Orchard, church spire. | 42 09 32.02 | 988.0 | 72 30 07.04 | 161.6 |
| Indian Orchard, French Catholic church spire. | 42 09 33.30 | 1027.4 | 72 29 59.96 | 1376.5 |
| Indian Orchard, Congregational church tower. | 42 09 24.98 | 770.7 | 72 30 25.45 | 584.3 |
| Jenksville church tower (1). | 42 09 31.91 | 984.6 | 72 29 06.70 | 153.8 |
| Jenksville church tower (2). | 42 09 30.19 | 931.5 | 72 28 58.94 | 1353.1 |
| Wilson's (Foster) house, tower. | 42 12 50.94 | 1571.7 | 72 38 08.34 | 191.3 |
| Ludlow, Congregational church spire. | 42 11 30.41 | 938.3 | 72 27 37.86 | 868.7 |
| Ludlow, Methodist church spire. | 42 11 29.10 | 897.9 | 72 27 09.72 | 223.0 |
| Palmer, Universalist church spire. | 42 09 28.06 | 865.8 | 72 19 35.91 | 824.4 |
| Three Rivers, French Catholic church spire. | 42 11 00.72 | 22.2 | 72 21 21.30 | 488.8 |
| Granby, Congregational church spire. | 42 15 22.87 | 705.6 | 72 31 04.12 | 94.4 |
| Belchertown, High School tower. | 42 16 37.90 | 1169.4 | 72 24 11.95 | 273.8 |
| Belchertown, Baptist church tower. | 42 16 40.81 | 1259.2 | 72 24 04.66 | 106.8 |
| Belchertown, First Congregational church spire. | 42 16 42.68 | 1316.9 | 72 24 05.98 | 137.0 |
| Belchertown, Methodist church tower. | 42 16 42.12 | 1299.6 | 72 24 10.26 | 235.1 |
| Easthampton, Williston Mill tower. | 42 16 27.69 | 854.4 | 72 39 33.42 | 765.9 |
| Easthampton, Methodist church tower. | 42 16 15.79 | 487.2 | 72 40 22.28 | 510.6 |
| Easthampton, Williston Seminary gymnasium tower. | 42 16 13.85 | 427.4 | 72 40 16.00 | 366.7 |
| Easthampton, First Congregational church spire. | 42 16 20.74 | 639.9 | 72 40 17.24 | 395.1 |
| Easthampton, Payson Congregational church spire. | 42 16 12.02 | 370.9 | 72 40 22.78 | 522.0 |
| Easthampton, town hall tower. | 42 16 16.66 | 514.1 | 72 40 21.85 | 500.7 |
| Easthampton, Williston, Knight & Co.'s chimney. | 42 16 00.90 | 27.8 | 72 40 11.40 | 261.3 |

**CONNECTICUT RIVER VALLEY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 100 00 08 | 279 50 55 | Brush | 19228.7 | 4.28395 |
| 168 04 21 | 348 03 14 | Facing Rock. | 11112.2 | 4.04580 |
| 127 19 10 | 307 13 15 | Mount Tom | 15222.6 | 4.18249 |
| 207 31 44 | 27 33 26 | Facing Rock. | 7544.8 | 3.87765 |
| 126 50 08 | 306 44 09 | Mount Tom | 15327.8 | 4.18548 |
| 266 33 18 | 26 34 55 | Facing Rock. | 7436.0 | 3.87134 |
| 119 44 45 | 299 39 26 | Crafts | 12549.3 | 4.09862 |
| 209 30 18 | 29 32 13 | Facing Rock. | 7937.8 | 3.89970 |
| 115 20 33 | 295 14 21 | Crafts | 14054.3 | 4.14781 |
| 197 26 40 | 17 27 41 | Facing Rock. | 7016.2 | 3.84610 |
| 115 13 46 | 295 07 29 | Crafts | 14238.4 | 4.15346 |
| 195 55 31 | 15 56 27 | Facing Rock. | 7015.8 | 3.84608 |
| 63 45 50 | 243 45 42 | Crafts | 310.0 | 2.49132 |
| 160 49 44 | 340 49 12 | Mount Tom. | 3262.1 | 3.51350 |
| 181 13 57 | 1 13 59 | Facing Rock | 3037.7 | 3.48254 |
| 109 46 36 | 289 39 01 | Mount Tom. | 16499.9 | 4.21748 |
| 109 10 42 | 289 02 49 | Mount Tom | 17121.8 | 4.23355 |
| 169 19 54 | 349 19 37 | Facing Rock. | 3131.5 | 3.49575 |
| 5 23 32 | 185 22 58 | Peaked Mount | 12306.9 | 4.09015 |
| 145 33 27 | 325 32 52 | Dumpling. | 2109.8 | 3.32424 |
| 312 22 58 | 132 23 34 | Dumpling | 1659.4 | 3.21995 |
| 131 31 45 | 311 28 18 | Rock Rimmon. | 9425.8 | 3.97432 |
| 310 45 31 | 130 47 52 | Facing Rock | 6331.8 | 3.80153 |
| 45 22 21 | 225 16 35 | Brush. | 16631.1 | 4.22092 |
| 79 07 04 | 258 57 10 | Mount Tom | 20618.6 | 4.31426 |
| 130 06 58 | 310 00 11 | North Warner. | 18126.8 | 4.25832 |
| 69 51 12 | 249 41 38 | Crafts | 20909.8 | 4.32035 |
| 37 56 33 | 217 54 56 | Rock Rimmon. | 5385.3 | 3.73121 |
| 78 47 27 | 258 37 29 | Mount Tom | 20780.7 | 4.31766 |
| 136 49 58 | 316 45 15 | College Chapel. | 14079.9 | 4.14860 |
| 78 47 04 | 258 37 08 | Mount Tom | 20681.4 | 4.31553 |
| 137 10 30 | 317 05 49 | College Chapel. | 14025.2 | 4.14691 |
| 227 11 24 | 47 17 05 | College Chapel | 15796.1 | 4.19855 |
| 346 17 23 | 166 17 49 | Mount Tom. | 3712.4 | 3.56966 |
| 214 12 44 | 34 16 46 | Mount Warner | 14654.1 | 4.46596 |
| 328 18 27 | 148 19 26 | Mount Tom. | 3806.9 | 3.58057 |
| 228 22 26 | 48 28 36 | College Chapel | 16805.8 | 4.22546 |
| 329 43 44 | 149 44 38 | Mount Tom. | 3681.4 | 3.56601 |
| 214 10 30 | 34 14 29 | Mount Warner | 14463.1 | 4.16026 |
| 330 56 39 | 150 57 34 | Mount Tom. | 3879.9 | 3.58882 |
| 213 59 41 | 34 03 44 | Mount Warner | 14757.1 | 4.16900 |
| 327 12 57 | 147 13 56 | Mount Tom. | 3714.6 | 3.56991 |
| 214 14 23 | 34 18 25 | Mount Warner | 14626.5 | 4.16514 |
| 328 38 47 | 148 39 45 | Mount Tom. | 3824.6 | 3.58259 |
| 212 25 41 | 32 29 36 | Mount Warner | 14901.2 | 4.17322 |
| 327 48 01 | 147 48 52 | Mount Tom. | 3285.1 | 3.51655 |

**CONNECTICUT RIVER VALLEY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| West Hampton, Congregational church spire. | 42 18 16.57 | 511.3 | 72 46 32.39 | 741.9 |
| Northhampton, First Congregational church spire. | 42 19 09.25 | 285.4 | 72 37 53.14 | 1216.9 |
| Northhampton, Second Congregational church spire. | 42 19 04.62 | 142.6 | 72 38 04.32 | 98.9 |
| Northhampton, Catholic church tower. | 42 19 38.61 | 1191.3 | 72 38 02.98 | 68.2 |
| Northhampton, lunatic asylum tower. | 42 18 52.16 | 1609.4 | 72 38 51.00 | 1168.0 |
| Northhampton, Methodist church spire. | 42 19 10.72 | 330.8 | 72 37 59.58 | 1364.3 |
| Northhampton, Episcopal church spire. | 42 19 16.38 | 505.4 | 72 37 42.57 | 974.8 |
| Northhampton, Round Hill flagstaff. | 42 19 27.53 | 849.4 | 72 38 22.38 | 512.4 |
| Nonotuck Hotel tower. | 42 16 47.86 | 1476.7 | 72 37 15.19 | 348.1 |
| Connecticut River Lumber Company's chimney. | 42 17 29.65 | 914.8 | 72 37 14.30 | 327.6 |
| Mount Holyoke Hotel flagstaff. | 42 18 02.12 | 65.4 | 72 35 17.62 | 403.6 |
| South Amherst, Monson's barn cupola. | 42 20 36.78 | 1134.9 | 72 30 24.64 | 564.0 |
| South Amherst, church spire. | 42 20 25.45 | 785.3 | 72 30 13.94 | 319.1 |
| Smith's (Edwin) barn, cupola. | 42 20 56.34 | 1738.4 | 72 33 10.66 | 244.0 |
| Hadley, First Congregational church spire. | 42 20 30.88 | 952.8 | 72 35 20.81 | 476.4 |
| Hadley, Second Congregational church spire. | 42 20 33.90 | 1046.0 | 72 35 47.72 | 1092.3 |
| New Braintree, Congregational church spire. | 42 19 01.16 | 35.8 | 72 07 35.90 | 822.1 |
| Florence, engine-house tower. | 42 20 04.52 | 139.5 | 72 40 19.43 | 444.8 |
| Florence, Catholic church spire. | 42 19 56.78 | 1752.0 | 72 40 07.03 | 160.9 |
| Florence, Congregational church spire. | 42 19 54.16 | 1671.1 | 72 40 30.00 | 686.8 |
| Florence, school-house tower. | 42 19 51.98 | 1603.8 | 72 40 33.41 | 764.9 |
| Florence, Methodist church spire. | 42 20 07.18 | 221.5 | 72 40 25 22 | 577.4 |
| Florence, Cosmian Hall clock tower. | 42 20 09.26 | 285.7 | 72 40 26.55 | 607.8 |

CONNECTICUT RIVER VALLEY—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 303 34 06 | 123 39 14 | Mount Tom | 12583. 5 | 4. 09980 |
| 308 19 17 | 128 36 49 | Peaked Mount. | 45910. 3 | 4. 66191 |
| 144 18 16 | 324 15 30 | Shingle Hill | 9657. 2 | 3. 98485 |
| 215 31 06 | 35 33 28 | Mount Warner. | 8309. 4 | 3. 91957 |
| 216 21 12 | 36 23 42 | Mount Warner | 8575. 3 | 3. 93325 |
| 7 50 24 | 187 49 50 | Mount Tom. | 8528. 1 | 3. 93085 |
| 220 46 46 | 40 49 15 | Mount Warner | 7735. 7 | 3. 88850 |
| 142 03 10 | 322 00 31 | Shingle Hill. | 8796. 7 | 3. 94432 |
| 239 24 52 | 59 30 05 | College Chapel | 12333. 4 | 4. 09108 |
| 0 39 28 | 180 39 25 | Mount Tom. | 8064. 7 | 3. 90659 |
| 144 51 55 | 324 49 14 | Shingle Hill | 9534. 5 | 3. 97930 |
| 238 52 18 | 58 56 56 | College Chapel. | 11029. 4 | 4. 04255 |
| 142 22 22 | 322 19 29 | Shingle Hill | 9625. 0 | 3. 98340 |
| 215 01 27 | 35 03 42 | Mount Warner. | 7290. 1 | 3. 90255 |
| 221 33 38 | 41 36 20 | Mount Warner | 8285. 0 | 3. 91831 |
| 242 30 51 | 62 35 44 | College Chapel. | 11230. 5 | 4. 05040 |
| 151 57 16 | 331 54 05 | Shingle Hill | 13829. 9 | 4. 14082 |
| 199 35 25 | 19 37 21 | Mount Warner. | 11808. 6 | 4. 07220 |
| 201 49 39 | 21 51 35 | Mount Warner | 10596. 2 | 4. 02515 |
| 223 37 30 | 43 41 37 | College Chapel. | 12181. 8 | 4. 08571 |
| 137 10 32 | 317 06 02 | Shingle Hill | 13522. 3 | 4. 13104 |
| 188 10 44 | 8 11 21 | Mount Warner. | 8923. 8 | 3. 95055 |
| 126 47 27 | 306 44 47 | Mount Warner | 6784. 1 | 3. 83149 |
| 162 19 52 | 342 19 24 | College Chapel. | 3190. 1 | 3. 50380 |
| 127 51 18 | 307 48 31 | Mount Warner | 7190. 8 | 3. 85678 |
| 160 18 31 | 340 17 55 | College Chapel. | 3599. 6 | 3. 55626 |
| 110 36 02 | 290 30 06 | Shingle Hill | 12922. 3 | 4. 11134 |
| 154 41 24 | 334 40 36 | Mount Warner. | 3824. 8 | 3. 58261 |
| 120 17 45 | 300 13 16 | Shingle Hill | 10560. 9 | 4. 02370 |
| 197 33 25 | 17 34 04 | Mount Warner. | 4450. 3 | 3. 64839 |
| 121 36 46 | 301 32 36 | Shingle Hill | 9984. 8 | 3. 99934 |
| 205 15 25 | 25 16 23 | Mount Warner. | 4589. 0 | 3. 66172 |
| 30 38 05 | 210 29 27 | Peaked Mountain | 34764. 8 | 4. 54114 |
| 71 49 19 | 251 36 37 | Rock Rimmon. | 27346. 4 | 4. 43690 |
| 159 32 42 | 339 31 35 | Shingle Hill | 6548. 2 | 3. 81612 |
| 252 15 01 | 72 21 13 | College Chapel. | 13272. 7 | 4. 12296 |
| 236 06 48 | 56 10 40 | Mount Warner | 9504. 7 | 3. 97794 |
| 350 41 06 | 170 41 54 | Mount Tom. | 10192. 5 | 4. 00828 |
| 237 24 20 | 57 28 28 | Mount Warner | 9989. 6 | 3. 99955 |
| 347 41 26 | 167 42 30 | Mount Tom. | 10211. 5 | 4. 00909 |
| 347 10 50 | 167 11 56 | Mount Tom | 10162. 7 | 4. 00701 |
| 163 12 19 | 343 11 21 | Shingle Hill. | 6813. 0 | 3. 83334 |
| 160 23 43 | 340 22 40 | Shingle Hill | 6425. 8 | 3. 80793 |
| 239 03 37 | 59 07 41 | Mount Warner. | 9685. 0 | 3. 98610 |
| 160 27 36 | 340 26 34 | Shingle Hill | 6354. 9 | 3. 80311 |
| 253 03 30 | 73 09 47 | College Chapel. | 13384. 7 | 4. 12661 |

**CONNECTICUT RIVER VALLEY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Florence Manufacturing Company's mill tower. | 42 19 53.57 | 1652.9 | 72 40 44.64 | 1022.0 |
| Hatfield, Congregational church spire. | 42 22 13.68 | 422.1 | 72 35 50.97 | 1166.2 |
| Hatfield, Smith Academy tower. | 42 22 15.68 | 483.8 | 72 35 44.70 | 1022.8 |
| North Hadley, Congregational church spire. | 42 23 19.71 | 608.2 | 72 34 52.02 | 1189.9 |
| Haydensville, Catholic church spire. | 42 22 22.87 | 705.7 | 72 41 53.70 | 1228.6 |
| Haydensville, Congregational church spire. | 42 21 15.34 | 473.3 | 72 41 39.08 | 894.4 |
| Amherst, College Hall. | 42 22 22.02 | 679.4 | 72 31 14.42 | 329.9 |
| Amherst, Williston Hall tower. | 42 22 17.76 | 548.0 | 72 31 06.59 | 150.8 |
| Amherst, Walker Hall tower. | 42 22 18.21 | 561.9 | 72 31 02.82 | 64.5 |
| Amherst, Episcopal church spire. | 42 22 29.76 | 918.2 | 72 31 09.06 | 207.3 |
| Amherst, Congregational church spire. | 42 22 32.07 | 989.5 | 72 31 00.60 | 13.7 |
| Amherst Agricultural College drill-hall tower. | 42 23 17.06 | 526.4 | 72 31 43.56 | 996.4 |
| Amherst Agricultural College flagstaff. | 42 23 21.69 | 669.3 | 72 31 42.64 | 975.4 |
| Amherst Agricultural College belfry. | 42 23 26.31 | 811.8 | 72 31 46.50 | 1063.6 |
| Amherst, Lawrence observatory equatorial cover, center. | 42 22 17.06 | 526.4 | 72 31 10.05 | 229.9 |
| Amherst City, Methodist church tower. | 42 24 50.34 | 1553.2 | 72 30 32.79 | 749.7 |
| Pelham church spire | 42 23 32.30 | 996.6 | 72 24 17.34 | 396.6 |
| North Amherst, Congregational church spire. | 42 24 36.74 | 1133.6 | 72 31 52.29 | 1195.7 |
| Dickinson's (Charles R.) barn cupola. | 42 25 23.87 | 736.5 | 72 31 49.77 | 1137.8 |
| Deacon Elihu's barn tower. | 42 26 06.46 | 199.3 | 72 35 22.80 | 521.1 |
| Whately, Congregational church spire. | 42 26 17.07 | 526.7 | 72 38 07.34 | 167.8 |
| Conway Township, southeast corner. | 42 27 30.25 | 933.4 | 72 39 28.34 | 647.5 |
| Chestnut Hill. | 42 24 34.29 | 1058.0 | 72 39 40.12 | 917.4 |

**CONNECTICUT RIVER VALLEY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 345 50 28 | 165 51 42 | Mount Tom | 10270.7 | 4.01160 |
| 165 11 14 | 345 10 24 | Shingle Hill. | 6695.8 | 3.82580 |
| 242 12 25 | 62 13 25 | Mount Warner | 2297.6 | 3.36128 |
| 131 07 17 | 311 02 23 | High Ridge. | 13215.4 | 4.12108 |
| 147 51 26 | 327 48 37 | Mount Esther | 10735.0 | 4.03080 |
| 241 52 50 | 61 53 46 | Mount Warner. | 2141.9 | 3.33080 |
| 135 49 00 | 315 45 36 | Mount Esther | 9921.8 | 3.99659 |
| 236 09 06 | 56 12 05 | Dickinson. | 7304.5 | 3.86359 |
| 175 57 26 | 355 57 22 | Shingle Hill | 1870.9 | 3.27204 |
| 344 17 34 | 164 19 34 | Mount Tom. | 15129.3 | 4.17982 |
| 192 17 42 | 12 18 52 | Mount Esther | 11207.0 | 4.04949 |
| 343 13 55 | 163 15 45 | Mount Tom. | 13035.3 | 4.11512 |
| 36 00 30 | 215 55 20 | Mount Tom | 17963.9 | 4.25440 |
| 100 44 44 | 280 42 38 | Mount Warner. | 4370.8 | 3.64056 |
| 6 21 56 | 186 21 56 | College Chapel | 76.6 | 1.88429 |
| 101 56 49 | 281 54 37 | Mount Warner. | 4572.3 | 3.66013 |
| 101 33 34 | 281 31 19 | Mount Warner | 4653.9 | 3.66782 |
| 187 53 30 | 7 53 54 | Dickinson. | 6020.6 | 3.77964 |
| 353 51 42 | 173 51 43 | College Chapel | 449.1 | 2.65232 |
| 97 25 58 | 277 23 48 | Mount Warner. | 4454.0 | 3.64875 |
| 15 43 02 | 195 42 58 | College Chapel | 537.7 | 2.73054 |
| 96 15 14 | 276 12 58 | Mount Warner. | 4637.6 | 3.66629 |
| 31 21 50 | 211 17 00 | Mount Tom | 19008.2 | 4.27894 |
| 79 35 20 | 259 33 36 | North Warner. | 3590.7 | 3.55518 |
| 338 16 30 | 158 16 54 | College Chapel | 2205.6 | 3.34352 |
| 77 25 42 | 257 23 57 | North Warner. | 3639.7 | 3.56107 |
| 337 33 55 | 157 34 22 | College Chapel | 2370.8 | 3.37489 |
| 74 53 59 | 254 52 17 | North Warner. | 3587.9 | 3.55484 |
| 105 37 40 | 285 35 34 | North Warner | 4463.1 | 3.64964 |
| 189 23 18 | 9 23 47 | Dickinson. | 6080.8 | 3.78396 |
| 55 36 00 | 235 33 28 | North Warner | 6242.1 | 3.79533 |
| 186 18 04 | 6 18 08 | Dickinson. | 1277.1 | 3.10624 |
| 50 20 48 | 230 10 58 | Mount Tom | 26137.3 | 4.41726 |
| 85 23 33 | 265 16 47 | North Warner. | 13784.1 | 4.13938 |
| 27 24 42 | 207 19 58 | Mount Tom | 21053.8 | 4.32333 |
| 105 32 45 | 285 25 10 | High Ridge. | 15995.2 | 4.20399 |
| 36 36 34 | 216 34 54 | North Warner | 5683.3 | 3.75460 |
| 262 56 42 | 82 57 38 | Dickinson. | 1914.5 | 3.28206 |
| 61 00 49 | 240 56 22 | Shingle Hill | 10372.7 | 4.01589 |
| 107 35 36 | 287 32 33 | Mount Esther. | 6516.3 | 3.81400 |
| 277 33 55 | 97 39 05 | Dickinson | 10624.0 | 4.02629 |
| 319 45 54 | 139 48 29 | North Warner. | 8124.7 | 3.90981 |
| 319 59 10 | 140 02 39 | North Warner | 11044.3 | 4.04314 |
| 44 09 32 | 224 09 14 | Mount Esther. | 862.5 | 2.93578 |
| 55 31 54 | 235 30 20 | Shingle Hill | 3866.2 | 3.58728 |
| 132 39 07 | 312 36 48 | High Ridge. | 6416.2 | 3.80728 |

**CONNECTICUT RIVER VALLEY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Battlecock. | 42 23 02.75 | 84.8 | 72 46 25.47 | 582.7 |
| Leverett, Congregational church spire. | 42 27 07.80 | 240.7 | 72 30 06.90 | 157.7 |
| Sunderland, school-house tower. | 42 28 02.32 | 71.6 | 72 34 44.74 | 1022.1 |
| Sunderland, Congregational church spire. | 42 27 57.91 | 1786.9 | 72 34 49.70 | 1135.4 |
| Mount Toby. | 42 29 16.32 | 503.6 | 72 32 16.28 | 371.8 |
| Shutesbury, Congregational church spire. | 42 27 11.85 | 365.6 | 72 24 37.34 | 853.2 |
| Shutesbury, Baptist church spire. | 42 27 10.31 | 318.1 | 72 24 36.46 | 833.1 |
| Shutesbury, house, chimney. | 42 27 42.20 | 1302.1 | 72 24 41.61 | 950.7 |
| Boyden's (Col.) barn cupola. | 42 28 58.00 | 1789.6 | 72 36 51.15 | 1168.3 |
| South Deerfield, Congregational church spire. | 42 28 44.71 | 1379.6 | 72 36 27.16 | 620.4 |
| Sugarloaf Hotel, south chimney. | 42 28 13.00 | 401.1 | 72 35 32.98 | 753.4 |
| Sugarloaf Hotel, north chimney. | 42 28 13.30 | 410.4 | 72 35 33.08 | 755.7 |

**CONNECTICUT RIVER VALLEY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 264 00 39 | 84 03 38 | Shingle Hill | 6118.0 | 3.78661 |
| 326 48 44 | 146 53 48 | Mount Tom. | 18865.6 | 4.27567 |
| 36 28 33 | 216 25 44 | North Warner | 9659.6 | 3.98496 |
| 88 48 56 | 268 40 10 | High Ridge. | 17821.7 | 4.25095 |
| 356 17 10 | 176 17 28 | North Warner | 9472.0 | 3.97644 |
| 79 47 51 | 259 42 12 | High Ridge. | 11653.1 | 4.06644 |
| 355 32 19 | 175 32 40 | North Warner | 9344.2 | 3.97054 |
| 78 05 46 | 258 02 20 | Mount Esther. | 7121.1 | 3.85255 |
| 13 20 26 | 193 19 04 | North Warner | 12060.4 | 4.08136 |
| 69 39 19 | 249 34 10 | Mount Esther. | 11170.7 | 4.04808 |
| 73 36 47 | 253 25 04 | Shingle Hill | 24846.2 | 4.39526 |
| 89 56 46 | 269 46 27 | Mount Esther. | 20960.4 | 4.32140 |
| 73 43 54 | 253 32 11 | Shingle Hill | 24853.1 | 4.39538 |
| 90 04 36 | 269 54 16 | Mount Esther. | 20980.2 | 4.32181 |
| 56 13 19 | 236 06 50 | North Warner | 15861.3 | 4.20034 |
| 71 29 35 | 251 17 55 | Shingle Hill. | 25034.6 | 4.39854 |
| 51 34 43 | 231 32 39 | Mount Esther | 5351.4 | 3.72847 |
| 66 11 14 | 246 07 00 | High Ridge. | 9378.4 | 3.97213 |
| 344 38 12 | 164 39 39 | North Warner | 11158.1 | 4.04759 |
| 58 25 02 | 238 22 42 | Mount Esther. | 5565.7 | 3.74552 |
| 350 02 31 | 170 03 22 | North Warner | 9930.7 | 3.99698 |
| 76 59 25 | 256 54 19 | High Ridge. | 10639.5 | 4.02692 |
| 44 40 11 | 224 35 50 | Shingle Hill | 12571.6 | 4.09939 |
| 76 56 24 | 256 51 18 | High Ridge. | 10639.5 | 4.02692 |

*Index of stations in Rhode Island.*

*Index of stations in Rhode Island.—Continued.*

*Index of stations in Rhode Island.—Continued.*

*Index of stations in Rhode Island.*—Continued.

PRIMARY STATIONS.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Blue Hill, astronomical azimuth station, Massachusetts, 1845. | 42 12 43.941 | 1355.7 | 71 06 52.638 | 1207.3 |
| Copecut, astronomical azimuth station, Massachusetts, 1844 (C. & G. S. & B.). | 41 43 17.245 | 532.1 | 71 03 36.644 | 847.1 |
| Beaconpole, astronomical azimuth station, 1844. | 41 59 42.468 | 1310.2 | 71 27 01.257 | 28.9 |
| Great Meadow, Massachusetts (C. & G. S. & B.). | 41 52 45.138 | 1392.7 | 71 13 02.292 | 52.9 |
| Massachusetts North Base, Massachusetts. 1844. | 42 03 06.592 | 203.4 | 71 12 24.871 | 572.0 |
| Massachusetts South Base, Massachusetts. 1844. | 41 54 49.921 | 1540.3 | 71 18 16.114 | 371.3 |

SECONDARY STATIONS.

| | | | | |
|---|---|---|---|---|
| Spencer, astronomical azimuth station, 1844. | 41 40 43.256 | 1334.4 | 71 29 40.685 | 941.0 |
| Quaker (C. & G. S. & B.). | 41 34 57.376 | 1770.1 | 71 15 18.337 | 424.7 |
| Cuttyhunk, Massachusetts (C. & G. S. & B.). | 41 25 14.887 | 459.3 | 70 56 02.646 | 61.4 |
| McSparran. | 41 29 46.953 | 1448.5 | 71 27 24.737 | 573.7 |
| Pocasset (C. & G. S. & B.). | 41 39 09.420 | 290.6 | 71 11 32.364 | 748.9 |
| East Rock. | 41 27 04.650 | 143.4 | 71 11 38.340 | 889.9 |
| Nootas, Massachusetts. | 41 32 13.020 | 401.6 | 71 07 25.832 | 598.8 |
| Block Island. | 41 10 32.077 | 989.5 | 71 35 30.644 | 714.3 |
| Broad Hill. | 41 24 39.953 | 1232.5 | 71 33 42.824 | 994.6 |
| Champlin. | 41 29 16.000 | 493.6 | 71 46 47.766 | 1108.2 |
| Lantern Hill, Connecticut. | 41 27 37.929 | 1170.1 | 71 56 40.826 | 947.5 |
| Watch Hill. | 41 18 49.932 | 1540.4 | 71 51 17.201 | 400.1 |
| College Hill. | 41 50 18.850 | 581.6 | 71 24 00.627 | 14.5 |
| Mount Hope. | 41 40 26.130 | 806.1 | 71 14 26.209 | 606.2 |
| Whitman. | 41 40 33.889 | 1045.5 | 71 27 19.357 | 447.6 |

**PRIMARY STATIONS.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 175 17 06.299 | 355 14 55.237 | Blue Hill | 54694.51 | 4.7379437 |
| 228 55 19.774 | 49 08 50.124 | Blue Hill | 36777.41 | 4.5655811 |
| 313 02 37.562 | 133 18 14.851 | Copecut. | 44425.23 | 4.6476297 |
| 123 44 56.597 | 303 35 35.905 | Beaconpole | 23223.72 | 4.3659318 |
| 192 54 36.214 | 12 58 43.781 | Blue Hill. | 37951.70 | 4.5792312 |
| 2 34 36.135 | 182 34 11.112 | Great Meadow | 19193.11 | 4.2831454 |
| 72 44 05.443 | 252 34 18.759 | Beaconpole. | 21123.09 | 4.3247575 |
| 207 47 11.966 | 27 51 06.916 | North Base | 17326.376 | 4.2387077 |
| 127 46 54.940 | 306 41 03.861 | Beaconpole. | 15091.32 | 4.1787273 |

**SECONDARY STATIONS.**

| | | | | |
|---|---|---|---|---|
| 185 57 36.34 | 5 59 22.68 | Beaconpole | 35339.35 | 4.5482586 |
| 262 22 17.91 | 82 39 38.36 | Copecut. | 36475.19 | 4.5619976 |
| 226 24 37.79 | 46 32 24.14 | Copecut | 22393.41 | 4.3501202 |
| 118 12 27.73 | 298 02 54.85 | Spencer. | 22634.29 | 4.3547668 |
| 123 56 41.52 | 303 43 55.71 | Quaker | 32270.72 | 4.5088086 |
| 162 33 26.03 | 342 28 24.78 | Copecut. | 35009.26 | 4.5441829 |
| 171 10 21.59 | 351 08 51.35 | Spencer | 20491.06 | 4.3115644 |
| 240 18 12.34 | 60 26 14.04 | Quaker. | 19370.85 | 4.2871487 |
| 150 41 04.12 | 330 30 44.69 | Beaconpole | 43666.53 | 4.6401487 |
| 235 09 32.46 | 55 14 48.84 | Copecut. | 13397.89 | 4.1270365 |
| 160 44 27.59 | 340 42 01.77 | Quaker | 15450.37 | 4.1889388 |
| 278 46 25.33 | 98 56 44.56 | Cuttyhunk. | 21986.15 | 4.3421491 |
| 309 04 33.44 | 129 12 05.94 | Cuttyhunk | 20436.54 | 4.3104073 |
| 156 03 33.63 | 336 00 49.97 | Pocasset. | 14058.13 | 4.1479275 |
| 197 33 03.29 | 17 38 24 22 | McSparran | 37376.15 | 4.5725945 |
| 227 16 59.28 | 47 32 44.86 | East Rock. | 45250.01 | 4.6556187 |
| 5 29 19.04 | 185 28 07.89 | Block Island | 26276.50 | 4.4195676 |
| 222 46 57.27 | 42 51 07.57 | McSparran. | 12911.69 | 4.1109830 |
| 335 30 49.75 | 155 38 16.93 | Block Island | 38080.36 | 4.5807010 |
| 267 51 56.97 | 88 04 47.49 | McSparran. | 26995.50 | 4.4312914 |
| 316 51 10.25 | 137 05 08.88 | Block Island | 43293.35 | 4.6364212 |
| 257 32 43.91 | 77 39 16.69 | Champlin. | 14089.65 | 4.1489001 |
| 304 46 59.34 | 124 57 23.39 | Block Island | 26863.71 | 4.4291660 |
| 155 15 02.20 | 335 11 28.24 | Lantern Hill. | 17940.44 | 4.2538331 |
| 253 23 08.32 | 73 30 27.63 | Great Meadow | 15841.36 | 4.1997926 |
| 7 06 04.06 | 187 03 48.37 | McSparran. | 38298.07 | 4.5831769 |
| 6 47 22.05 | 186 46 47.42 | Quaker | 10213.98 | 4.0091950 |
| 300 27 25.96 | 120 29 21.52 | Pocasset. | 4666.63 | 3.6690033 |
| 276 41 44.91 | 96 52 14.43 | Pocasset | 22063.36 | 4.3436717 |
| 0 21 29.76 | 180 21 26.18 | McSparran. | 19959.02 | 4.3001393 |

## SAKONNET RIVER AND MOUNT HOPE BAY.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Simmons. | 41 29 32.288 | 996.2 | 71 09 34.214 | 793.5 |
| Quicksand, Massachusetts. | 41 30 01.683 | 51.9 | 71 07 12.194 | 282.8 |
| Nootas (Borden), Massachusetts. | 41 32 13.094 | 404.0 | 71 07 25.874 | 599.8 |
| Wing. | 41 35 23.225 | 716.7 | 71 11 10.352 | 239.8 |
| Paradise Rock. | 41 30 05.511 | 169.9 | 71 15 45.504 | 1055.3 |
| Windmill 2. 1869. | 41 32 33.559 | 1035.2 | 71 11 50.508 | 1170.6 |
| Simmons 2. 1870. | 41 29 32.078 | 989.7 | 71 09 34.665 | 804.1 |
| Little Compton. | 41 31 12.385 | 382.2 | 71 11 00.706 | 16.3 |
| Little Compton 2. 1870. | 41 31 12.440 | 383.7 | 71 11 01.694 | 39.3 |
| Little Compton, church spire. | 41 30 33.635 | 1037.5 | 71 10 18.351 | 425.5 |
| Church's Point 2. 1869. | 41 30 09.917 | 305.9 | 71 12 21.012 | 487.2 |
| South Portsmouth, Episcopal church tower. | 41 32 50.304 | 1551.9 | 71 15 42.342 | 981.4 |
| South Portsmouth, Union church tower. | 41 33 30.179 | 931.1 | 71 15 21.902 | 507.8 |
| Slate Hill, flagstaff. 1869. | 41 32 22.154 | 683.6 | 71 15 56.410 | 1307.4 |
| Fair grounds, tower. | 41 31 16.608 | 512.3 | 71 16 27.837 | 645.4 |
| Gibbs 2. 1869. | 41 29 39.540 | 1219.7 | 71 16 28.381 | 658.2 |
| Fogland Point House, north gable. | 41 33 42.896 | 1323.4 | 71 13 11.652 | 269.9 |
| North Windmill. | 41 35 16.013 | 494.0 | 71 15 16.018 | 371.0 |
| Mount Hope 2. 1874. | 41 40 26.515 | 818.0 | 71 14 26.094 | 603.6 |
| Mound. | 41 38 14.042 | 433.2 | 71 13 11.906 | 275.4 |
| Quicksand 2, Massachusetts. 1870. | 41 29 56.40 | 1740.0 | 71 07 09.16 | 212.4 |
| Quicksand (Borden), Massachusetts. | 41 30 01.73 | 53.4 | 71 07 12.18 | 282.5 |
| Shaw's (Peter) barn, cupola. | 41 29 14.50 | 447.3 | 71 08 45.72 | 1060.6 |

**SAKONNET RIVER AND MOUNT HOPE BAY.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 210 58 02.0 | 30 59 27.1 | Nootas | 5783.7 | 3.762207 |
| 32 19 10.1 | 212 17 47.9 | East Rock. | 5388.9 | 3.731504 |
| 175 32 19.6 | 355 32 10.6 | Nootas | 4064.2 | 3.608975 |
| 74 37 19.5 | 254 35 45.4 | Simmons. | 3416.7 | 3.533609 |
| 309 04 44.8 | 129 12 17.3 | Cuttyhunk | 20438.7 | 4.310454 |
| 114 53 04.2 | 294 47 50.8 | Quaker. | 12064.5 | 4.081508 |
| 154 08 19.3 | 334 06 09.2 | Mount Hope | 10386.6 | 4.016473 |
| 82 07 08.5 | 262 04 23.9 | Quaker. | 5799.2 | 3.763371 |
| 213 01 28.1 | 33 04 30.6 | Wing | 11693.8 | 4.067957 |
| 314 11 29.3 | 134 14 12.9 | East Rock. | 8001.3 | 3.903161 |
| 132 40 28.7 | 312 38 10.8 | Quaker | 6548.1 | 3.816114 |
| 50 03 00.5 | 230 00 24.7 | Paradise Rock. | 7109.8 | 3.851855 |
| 96 52 18.7 | 276 48 13.0 | Paradise Rock | 8663.3 | 3.937683 |
| 32 15 42.2 | 212 14 20.3 | East Rock. | 5377.9 | 3.730613 |
| 139 19 18.0 | 319 16 27.1 | Quaker | 9155.9 | 3.961700 |
| 249 23 57.3 | 69 26 19.8 | Nootas. | 5321.2 | 3.726012 |
| 72 36 29.8 | 252 33 21.7 | Paradise Rock | 6897.9 | 3.838715 |
| 326 53 33.1 | 146 54 30.8 | Simmons 2. | 3696.0 | 3.567735 |
| 139 30 46.0 | 319 27 27.0 | Quaker | 10702.7 | 4.029492 |
| 139 59 16.9 | 319 58 48.2 | Little Compton 2. | 1563.1 | 3.193998 |
| 189 03 55.5 | 9 04 15.7 | Windmill 2. | 4487.5 | 3.652007 |
| 88 22 38.6 | 268 20 23.1 | Paradise Rock. | 4744.8 | 3.676216 |
| 188 04 23.9 | 8 04 39.8 | Quaker | 3959.6 | 3.597650 |
| 0 49 36.4 | 180 49 34.3 | Paradise Rock. | 5084.5 | 3.706246 |
| 181 45 30.8 | 1 45 33.2 | Quaker | 2691.3 | 3.429967 |
| 76 59 33.1 | 256 54 45.0 | Hull. | 10333.1 | 4.014232 |
| 356 33 58.4 | 176 34 05.6 | Paradise Rock | 4223.1 | 3.625628 |
| 266 26 40.9 | 86 29 24.0 | Windmill 2. | 5710.7 | 3.756691 |
| 67 54 33.6 | 247 53 07.7 | Miantonomy | 3243.5 | 3.511010 |
| 335 53 02.3 | 155 53 30.4 | Paradise Rock. | 2403.1 | 3.380763 |
| 231 08 26.9 | 51 08 55.3 | Paradise Rock | 1277.1 | 3.106234 |
| 120 40 10.9 | 300 38 44.5 | Miantonomy. | 3479.5 | 3.541511 |
| 318 40 21.9 | 138 41 15.7 | Windmill 2 | 2848.2 | 3.454567 |
| 128 04 07.4 | 308 02 43.4 | Quaker. | 3727.6 | 3.571424 |
| 5 20 12.2 | 185 20 10.7 | Quaker | 577.5 | 2.761554 |
| 113 13 14.1 | 293 10 57.5 | Prudence 2. | 5185.4 | 3.714779 |
| 62 15 31.6 | 242 11 25.8 | Pine Hill | 9668.8 | 3.985375 |
| 6 47 47.5 | 186 47 12.8 | Quaker. | 10226.1 | 4.009711 |
| 157 13 25.6 | 337 12 36.3 | Mount Hope 2 | 4432.8 | 3.646681 |
| 25 46 07.3 | 205 44 43.3 | Quaker. | 6736.7 | 3.828449 |
| 113 31 48 | 293 29 14 | Little Compton 2 | 5880.7 | 3.76943 |
| 77 28 34 | 257 26 58 | Simmons 2. | 3457.5 | 3.53876 |
| 175 31 13 | 355 31 04 | Nootas (Borden) | 4065.1 | 3.60907 |
| 299 36 00 | 119 43 23 | Cuttyhunk. | 17881.7 | 4.25241 |
| 115 31 56 | 295 31 24 | Simmons | 1258.2 | 3.09976 |
| 239 59 56 | 60 01 00 | Quicksand 2. | 2586.1 | 3.41265 |

**SAKONNET RIVER AND MOUNT HOPE BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Wilbur's windmill. | 41 29 24.36 | 751.7 | 71 11 02.56 | 59.4 |
| West Island, New York Club, flagstaff. 1869. | 41 27 00.81 | 25.0 | 71 11 59.03 | 1370.1 |
| Griswold's barn, south cupola. | 41 32 58.69 | 1810.7 | 71 14 20.83 | 482.8 |
| Howland's barn, cupola. | 41 32 04.17 | 128.6 | 71 11 46.08 | 1068.3 |
| Lawton's house, flagstaff. | 41 37 33.40 | 1030.4 | 71 12 48.97 | 1133.5 |
| Portsmouth, belfry. | 41 36 13.34 | 411.5 | 71 14 53.67 | 1242.7 |
| Potter's (Widow) barn. | 41 33 18.00 | 555.3 | 71 12 17.07 | 395.5 |
| Four Corners, belfry. | 41 34 31.52 | 972 3 | 71 11 22.41 | 519.1 |
| Balch's house, north chimney. | 41 29 00.51 | 15.7 | 71 16 20.91 | 485.1 |
| Butts. | 41 36 55.84 | 1722.7 | 71 15 06.56 | 151.9 |
| Butts 2. 1861. | 41 36 55.74 | 1719.6 | 71 15 07.48 | 173.2 |
| Anthony. | 41 38 46.35 | 1429.9 | 71 13 18.64 | 431.4 |
| Blackbeard (Massachusetts). | 41 40 28.88 | 891.0 | 71 10 58.83 | 1360.8 |
| Toweset. | 41 41 59.23 | 1827.3 | 71 14 33.74 | 780.2 |
| Spar Island. | 41 41 17.40 | 536.8 | 71 13 14.68 | 339.5 |
| Tivorton cupola. | 41 37 30.25 | 933.2 | 71 12 50.91 | 1178.5 |
| Barker. | 41 38 23.01 | 709.9 | 71 12 06.65 | 153.9 |
| Cornell. | 41 37 18.96 | 584.9 | 71 09 16.52 | 382.4 |
| Windmill. | 41 32 33.62 | 1037.2 | 71 11 50.48 | 1170.1 |
| Church's Point. | 41 30 00.12 | 3.7 | 71 12 23.96 | 555.7 |
| Gibbs. | 41 29 36.69 | 1131.9 | 71 16 29.18 | 676.9 |
| Sakonnet Point. | 41 27 16.36 | 504.7 | 71 11 46.09 | 1069.8 |
| High Hill. | 41 32 51.03 | 1574.3 | 71 12 59.46 | 1378.1 |

**SAKONNET RIVER AND MOUNT HOPE BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 263 19 56 | 83 20 54 | Simmons 2 | 2052.8 | 3.31235 |
| 180 20 44 | 0 20 45 | Little Compton 2 | 3334.4 | 3.52301 |
| 97 11 32 | 277 06 06 | Telegraph 2 | 11522.0 | 4.06153 |
| 137 20 18 | 317 17 48 | Paradise Rock. | 7751.1 | 3.88936 |
| 224 41 08 | 44 43 14 | Wing | 6273.6 | 3.79752 |
| 282 31 47 | 102 33 37 | Windmill 2. | 3569.2 | 3.55257 |
| 137 23 28 | 317 21 07 | Quaker | 7262.8 | 3.86110 |
| 173 32 27 | 353 32 24 | Windmill. | 912.6 | 2.96026 |
| 330 22 04 | 150 23 09 | Wing | 4619.7 | 3.66461 |
| 351 40 00 | 171 40 39 | Windmill 2. | 9348.8 | 3.97076 |
| 327 56 31 | 147 58 33 | Windmill 2 | 7998.7 | 3.90302 |
| 286 37 13 | 106 39 41 | Wing. | 5398.1 | 3.73224 |
| 126 08 50 | 306 06 50 | Quaker | 5199.9 | 3.71600 |
| 335 48 52 | 155 49 10 | Windmill 2. | 1502.8 | 3.17690 |
| 189 56 02 | 9 56 10 | Wing | 1619.7 | 3.20943 |
| 10 08 44 | 190 08 25 | Windmill 2. | 3696.7 | 3.56782 |
| 202 16 16 | 22 16 39 | Paradise Rock | 2167.1 | 3.33589 |
| 67 08 25 | 247 05 52 | Telegraph 2. | 5810.1 | 3.76418 |
| 297 33 40 | 117 36 17 | Wing | 6171.2 | 3.79037 |
| 4 16 17 | 184 16 09 | Quaker. | 3665.1 | 3.56408 |
| 104 45 03 | 284 41 25 | Pine Hill | 7858.5 | 3.89534 |
| 188 22 00 | 8 22 27 | Mount Hope. | 6560.5 | 3.81694 |
| 36 14 21 | 216 13 09 | Butts | 4226.5 | 3.62598 |
| 153 04 38 | 333 03 53 | Mount Hope. | 3452.6 | 3.53815 |
| 17 33 47 | 197 33 25 | Pocasset | 2571.2 | 3.41014 |
| 89 00 23 | 268 58 05 | Mount Hope. | 4797.7 | 3.68103 |
| 299 15 58 | 119 18 20 | Blackbeard | 5698.5 | 3.75576 |
| 356 31 47 | 176 31 51 | Mount Hope. | 2877.5 | 3.45902 |
| 46 17 39 | 226 16 51 | Mount Hope | 2288.9 | 3.35963 |
| 125 13 50 | 305 12 57 | Toweset. | 2237.8 | 3.34983 |
| 35 54 53 | 215 53 15 | Quaker | 5822.2 | 3.76509 |
| 157 53 23 | 337 52 20 | Mount Hope. | 5857.2 | 3.76769 |
| 34 59 50 | 214 57 43 | Quaker | 7742.3 | 3.88887 |
| 139 38 41 | 319 37 08 | Mount Hope. | 4985.6 | 3.69772 |
| 62 30 03 | 242 26 03 | Quaker | 9448.9 | 3.97538 |
| 137 19 03 | 317 17 33 | Pocasset. | 4636.9 | 3.66623 |
| 132 39 29 | 312 37 08 | Quaker | 6547.7 | 3.81609 |
| 166 07 11 | 346 05 26 | Mount Hope. | 15016.9 | 4.17658 |
| 156 13 52 | 336 11 56 | Quaker | 10021.4 | 4.00093 |
| 171 40 11 | 351 38 50 | Mount Hope. | 19520.0 | 4.29048 |
| 59 54 34 | 239 52 42 | Hazard | 4516.4 | 3.65479 |
| 122 03 32 | 302 02 07 | Miantonomy. | 3509.6 | 3.54526 |
| 160 55 58 | 340 53 37 | Quaker | 15050.1 | 4.17744 |
| 171 21 24 | 351 19 38 | Mount Hope. | 24646.2 | 4.39175 |
| 140 28 21 | 320 26 49 | Quaker | 5054.8 | 3.70370 |
| 171 52 00 | 351 51 02 | Mount Hope. | 14183.4 | 4.15178 |

**SAKONNET RIVER AND MOUNT HOPE BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Mount Hope (Borden). | 41 40 27.55 | 849.9 | 71 14 26.15 | 604.9 |
| Joe Sanford (Borden), Massachusetts. | 41 35 37.56 | 1158.7 | 71 07 55.53 | 1286.1 |
| Fall River (Massachusetts). | 41 42 39.25 | 1210.9 | 71 08 45.54 | 1052.8 |
| Toweset Neck (Borden). | 41 42 45.02 | 1388.9 | 71 13 36.28 | 838.7 |

**PROVIDENCE RIVER.**

| | | | | |
|---|---|---|---|---|
| Pawtucket dark spire, 1885. | 41 52 53.95 | 1664.5 | 71 23 05.06 | 116.7 |
| Pawtucket spire (Borden), 1836. | 41 52 36.04 | 1111.9 | 71 22 53.84 | 1241.5 |
| Arnold. | 41 45 14.48 | 446.7 | 71 23 41.75 | 964.6 |
| Kinnicut. | 41 47 47.84 | 1475.9 | 71 21 57.48 | 1327.1 |
| Fort Independence. | 41 47 34.44 | 1062.5 | 71 23 33.38 | 770.7 |
| Neutaconkanut. | 41 48 41.08 | 1267.4 | 71 28 03.06 | 70.6 |
| Batty's Farm. | 41 45 34.90 | 1076.7 | 71 24 35.80 | 827.0 |
| Prospect Hill. | 41 49 44.64 | 1377.2 | 71 24 20.85 | 481.1 |
| Bullock's Neck (Borden). | 41 44 42.27 | 1304.1 | 71 21 35.11 | 811.2 |
| Bullock's Neck. | 41 44 42.90 | 1323.5 | 71 21 27.69 | 639.8 |
| Bullock's Neck 2, 1863. | 41 44 43.00 | 1326.6 | 71 21 35.16 | 812.3 |
| Verification South Base (Borden), 1836, Massachusetts. | 41 50 13.04 | 402.3 | 71 21 28.68 | 661.8 |
| Verification North Base (Borden), 1836, Massachusetts. | 41 54 25.94 | 800.3 | 71 21 20.68 | 476.6 |
| Stevens. | 41 44 44.13 | 1361.5 | 71 22 56.05 | 1295.1 |
| Sable Point. | 41 46 02.38 | 73.4 | 71 22 06.14 | 141.8 |
| Pawtuxet (Borden). | 41 45 14.19 | 436.8 | 71 23 41.72 | 963.9 |
| Pawtuxet. | 41 45 56.80 | 1752.4 | 71 23 13.95 | 322.2 |

**SAKONNET RIVER AND MOUNT HOPE BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 300 55 58 | 120 57 54 | Pocasset | 4688. 3 | 3. 67102 |
| 6 46 05 | 186 45 30 | Quaker. | 10258. 0 | 4. 01106 |
| 353 46 48 | 173 47 08 | Nootas (Borden) | 6345. 6 | 3. 80247 |
| 83 08 51 | 263 03 57 | Quaker. | 10331. 1 | 4. 01415 |
| 62 29 50 | 242 26 03 | Mount Hope | 8884. 4 | 3. 94863 |
| '30 48 42 | 210 46 51 | Pocasset. | 7536. 0 | 3. 87714 |
| 271 29 33 | 91 32 46 | Fall River | 6723. 7 | 3. 82761 |
| 15 13 08 | 195 12 35 | Mount Hope (Borden). | 4394. 4 | 3. 64290 |

**PROVIDENCE RIVER.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| 156 40 20 | 336 37 42 | Beaconpole | 13728. 4 | 4. 13762 |
| 271 03 51 | 91 10 33 | Great Meadow. | 13901. 1 | 4. 14305 |
| 173 37 47 | 353 36 51 | Joe's Rock | 17290. 3 | 4. 23780 |
| 284 06 07 | 104 09 53 | Great Rock. | 8046. 8 | 3. 90562 |
| 304 39 29 | 124 45 39 | Mount Hope | 15622. 8 | 4. 19376 |
| 30 10 50 | 210 08 25 | Whitman. | 10012. 0 | 4. 00052 |
| 322 32 00 | 142 37 00 | Mount Hope | 17160. 1 | 4. 23452 |
| 29 05 06 | 209 01 32 | Whitman. | 15315. 8 | 4. 18514 |
| 316 12 33 | 136 18 37 | Mount Hope | 18290. 3 | 4. 26222 |
| 2 33 58 | 182 33 52 | Arnold. | 4322. 4 | 3. 63572 |
| 288 15 00 | 108 18 00 | Fort Independence | 6556. 6 | 3. 81668 |
| 316 32 36 | 136 35 30 | Arnold. | 8777. 3 | 3. 94336 |
| 140 13 05 | 320 10 47 | Neutaconkanut | 7476. 9 | 3. 87372 |
| 201 20 43 | 21 21 25 | Fort Independence. | 3960. 0 | 3. 59769 |
| 344 43 53 | 164 44 25 | Fort Independence | 4163. 0 | 3. 61941 |
| 69 07 15 | 249 04 47 | Neutaconkanut. | 5490. 1 | 3. 73958 |
| 306 19 38 | 126 26 19 | Pocasset | 17311. 8 | 4. 23834 |
| 334 10 54 | 154 15 04 | Quaker. | 20039. 7 | 4. 30189 |
| 107 28 18 | 287 26 49 | Arnold | 3247. 1 | 3. 51149 |
| 151 15 51 | 331 14 27 | Fort Independence. | 6036. 3 | 3. 78077 |
| 357 34 42 | 177 34 46 | Connimicut | 3129. 0 | 3. 49541 |
| 322 48 48 | 142 49 37 | Nayatt light-house, 1863. | 2802. 3 | 3. 44751 |
| 169 49 19 | 349 47 26 | Joe's Rock | 21942. 1 | 4. 34128 |
| 247 14 49 | 67 17 38 | Great Rock. | 6333. 1 | 3. 80161 |
| 313 25 31 | 133 28 14 | Great Rock | 7787. 7 | 3. 89141 |
| 1 21 22 | 181 21 17 | Verification South Base. | 7804. 4 | 3. 89234 |
| 271 03 49 | 91 04 43 | Bullock's Neck 2 | 1869. 4 | 3. 27170 |
| 327 39 00 | 147 39 58 | Connimicut. | 3741. 5 | 3. 57305 |
| 343 42 21 | 163 42 42 | Bullock's Neck 2 | 2551. 6 | 3. 40682 |
| 25 31 56 | 205 31 23 | Stevens. | 2675. 5 | 3. 42740 |
| 177 20 36 | 357 20 23 | College Hill | 9409. 4 | 3. 97356 |
| 288 35 09 | 108 36 33 | Bullock's Neck (Borden.). | 3086. 2 | 3. 48942 |
| 263 43 23 | 83 44 08 | Sable Point | 1575. 6 | 3. 19745 |
| 349 33 01 | 169 33 13 | Stevens. | 2279. 9 | 3. 35792 |

**PROVIDENCE RIVER**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Fort Independence 2, 1863. | 41 47 34.41 | 1061.6 | 71 23 33.49 | 773.3 |
| Kettle Point. | 41 47 46.34 | 1429.7 | 71 22 41.04 | 947.6 |
| Brown's house cupola. | 41 45 04.44 | 137.0 | 71 23 24.20 | 559.1 |
| Pawtuxet church spire, 1863. | 41 45 59.12 | 1823.9 | 71 23 30.53 | 705.2 |
| Vue de l'Eau Hotel. | 41 47 15.82 | 488.1 | 71 22 05.09 | 117.5 |
| Stargut Island house, northeast gable. | 41 47 10.00 | 308.5 | 71 22 55.92 | 1291.3 |
| Pierce's barn. | 41 48 22.47 | 693.2 | 71 22 59.79 | 1380.2 |
| Fox Point Rolling Mill, chimney. | 41 48 59.70 | 1841.8 | 71 23 55.82 | 1288.3 |
| Pomham. | 41 46 42.15 | 1300.4 | 71 21 28.04 | 647.6 |
| Pomham Beacon. 1843. | 41 46 35.13 | 1083.8 | 71 22 27.08 | 625.5 |
| Pawtuxet spire. 1843. | 41 45 59.34 | 1830.7 | 71 23 30.50 | 704.6 |
| Providence, Baptist church. | 41 49 38.92 | 1200.7 | 71 24 32.12 | 741.2 |
| Providence, Unitarian church. 1843. | 41 49 27.89 | 860.4 | 71 24 19.99 | 461.3 |
| Providence, Congregational church. | 41 49 12.90 | 398.0 | 71 24 50.78 | 1172.0 |
| Providence, Quaker College. | 41 50 00.56 | 17.3 | 71 23 56.34 | 1300.0 |
| Providence, High street church. | 41 49 05.73 | 176.8 | 71 25 16.25 | 375.1 |
| Providence, Unitarian church. 1863. | 41 49 27.88 | 860.1 | 71 24 20.08 | 463.4 |
| Providence Vitriol Works, chimney. | 41 49 49.56 | 1529.0 | 71 25 21.92 | 505.9 |
| Pawtuxet Beacon. 1843. | 41 45 35.56 | 1097.1 | 71 22 50.95 | 1177.0 |

**NARRAGANSETT BAY.**

| | | | | |
|---|---|---|---|---|
| Wickford. | 41 34 30.541 | 942.1 | 71 28 02.688 | 62.3 |
| Batty. | 41 32 13.240 | 408.5 | 71 22 36.230 | 839.9 |

**PROVIDENCE RIVER—Continued.**

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 324 36 03 | 144 37 01 | Sable Point | 3483.0 | 3.54195 |
| 351 28 30 | 171 28 43 | Pawtuxet. | 3045.1 | 3.48360 |
| 345 53 40 | 165 54 03 | Sable Point | 3307.0 | 3.51944 |
| 372 40 41 | 192 40 19 | Pawtuxet. | 3463.9 | 3.53957 |
| 225 14 44 | 45 15 36 | Sable Point | 2539.1 | 3.40468 |
| 284 42 17 | 104 43 30 | Bullock's Neck 2. | 2605.0 | 3.41580 |
| 178 40 04 | 358 40 02 | Fort Independence 2 | 2941.0 | 3.46850 |
| 267 01 52 | 87 02 48 | Sable Point. | 1951.8 | 3.29044 |
| 33 07 23 | 213 06 37 | Pawtuxet. | 2910.8 | 3.46401 |
| 105 42 04 | 285 41 05 | Fort Independence 2. | 2120.2 | 3.32638 |
| 130 58 06 | 310 57 41 | Fort Independence 2 | 1149.0 | 3.06031 |
| 197 02 04 | 17 02 14 | Kettle Point. | 1172.7 | 3.06919 |
| 338 46 28 | 158 46 40 | Kettle Point | 1195.9 | 3.07769 |
| 27 41 27 | 207 41 05 | Fort Independence 2. | 1674.5 | 3.22388 |
| 322 39 36 | 142 40 26 | Kettle Point | 2846.6 | 3.45432 |
| 348 54 53 | 168 55 08 | Fort Independence 2. | 2681.4 | 3.42836 |
| 319 54 55 | 139 59 36 | Mount Hope | 15153.7 | 4.18052 |
| 48 48 16 | 228 46 47 | Arnold. | 4105.4 | 3.61336 |
| 34 44 06 | 214 43 16 | Arnold | 3027.6 | 3.48110 |
| 140 05 19 | 320 04 35 | Fort Independence. | 2385.6 | 3.37760 |
| 309 12 13 | 129 18 15 | Mount Hope | 16247.3 | 4.21078 |
| 27 48 11 | 207 45 39 | Whitman. | 11349.3 | 4.05497 |
| 313 48 55 | 133 50 38 | Kinnicut | 4947.9 | 3.69442 |
| 0 38 48 | 180 38 46 | Batty's Farm. | 7529.4 | 3.87676 |
| 320 34 00 | 140 40 35 | Mount Hope | 21624.2 | 4.33494 |
| 14 08 08 | 194 06 09 | Whitman. | 16987.9 | 4.23014 |
| 318 20 19 | 138 27 15 | Mount Hope | 21734.5 | 4.33715 |
| 12 06 47 | 192 05 08 | Whitman. | 16376.5 | 4.21422 |
| 323 19 35 | 143 25 55 | Mount Hope | 22081.6 | 4.34403 |
| 15 02 07 | 194 59 52 | Whitman. | 18101.3 | 4.25771 |
| 304 20 32 | 124 22 15 | Kettle Point | 4340.2 | 3.63751 |
| 319 53 34 | 139 54 43 | Fort Independence 2. | 3683.0 | 3.56620 |
| 323 52 10 | 143 53 16 | Kettle Point | 3878.2 | 3.58863 |
| 342 55 07 | 162 55 38 | Fort Independence. | 3662.1 | 3.56373 |
| 315 39 24 | 135 41 11 | Kettle Point | 5314.1 | 3.72543 |
| 329 00 56 | 149 02 08 | Fort Independence. | 4862.8 | 3.68689 |
| 61 01 12 | 241 00 38 | Arnold | 1341.6 | 3.12763 |
| 165 02 50 | 345 02 22 | Fort Independence. | 3796.5 | 3.57938 |

**NARRAGANSETT BAY.**

| | | | | |
|---|---|---|---|---|
| 354 15 15.0 | 174 15 40.2 | McSparran | 8793.1 | 3.944141 |
| 239 47 37.2 | 59 56 39.4 | Mount Hope. | 21854.1 | 4.339532 |
| 56 01 21.0 | 235 58 09.7 | McSparran | 8069.9 | 3.906866 |
| 119 16 28.8 | 299 12 52.3 | Wickford. | 8670.5 | 3.938043 |

**NARRAGANSETT BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Prudence. | 41 36 24.417 | 753.3 | 71 18 42.589 | 986.2 |
| Slate. | 41 32 21.011 | 648.2 | 71 15 59.637 | 1382.3 |
| Miantonomy. | 41 30 37.049 | 1142.9 | 71 18 37.433 | 868.1 |
| Hazard. | 41 28 23.251 | 717.3 | 71 19 17.586 | 408.1 |
| Telegraph. | 41 27 47.828 | 1475.5 | 71 20 11.632 | 269.9 |
| Telegraph 2. 1869. | 41 27 47.279 | 1458.6 | 71 20 11.608 | 269.4 |
| Pine Hill. | 41 38 00.469 | 14.5 | 71 20 35.806 | 828.7 |
| Hull. | 41 32 14.564 | 449.3 | 71 22 36.229 | 839.9 |
| Dumplin 2. 1869. | 41 28 45.694 | 1409.6 | 71 22 07.834 | 181.8 |
| Dumplin. | 41 28 45.682 | 1409.3 | 71 22 07.859 | 182.3 |
| McSparran 2. 1869. | 41 29 47.786 | 1474.2 | 71 27 24.350 | 564.8 |
| Barber's Heights. | 41 31 44.871 | 1384.3 | 71 25 28.100 | 651.3 |
| Beavertail light-house. 1869. | 41 26 57.895 | 1786.1 | 71 23 59.574 | 1382.7 |
| Prudence 2. 1869. | 41 36 22.230 | 685.8 | 71 18 41.808 | 968.1 |
| High Rocks. | 41 37 47.560 | 1467.2 | 71 26 08.780 | 203.2 |
| Quonsett. | 41 35 26.582 | 820.1 | 71 24 33.702 | 780.6 |
| Quonsett 3. 1868. | 41 35 17.032 | 525.4 | 71 24 23.203 | 537.5 |
| Prudence South. | 41 34 44.455 | 1371.4 | 71 19 32.957 | 763.4 |
| Conanicut North. | 41 34 24.861 | 767.1 | 71 22 19.870 | 460.3 |
| Newport church. | 41 29 14.456 | 446.0 | 71 18 49.706 | 1153.1 |
| Hog Island 3. 1874. | 41 38 40.481 | 1248.8 | 71 16 50.822 | 1176.0 |
| Coal Mines, middle chimney. | 41 37 09.940 | 306.6 | 71 16 26.833 | 621.2 |
| Gould Island, barn cupola. | 41 32 02.029 | 62.6 | 71 20 41.058 | 951.9 |

**NARRAGANSETT BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 299 33 45.1 | 119 36 00.7 | Quaker | 5439.6 | 3.735563 |
| 34 57 28.3 | 214 54 53.2 | Batty. | 9452.5 | 3.975545 |
| 73 24 24.5 | 253 16 50.3 | McSparran | 16581.6 | 4.219627 |
| 88 32 34.5 | 268 28 11.5 | Batty. | 9196.3 | 3.963615 |
| 118 12 46.4 | 298 10 08.1 | Batty | 6281.8 | 3.798084 |
| 82 50 46.1 | 262 44 56.6 | McSparran. | 12326.9 | 4.090855 |
| 147 01 21.4 | 326 59 09.7 | Batty | 8459.8 | 3.927360 |
| 192 42 43.7 | 12 43 10.3 | Miantonomy. | 4231.5 | 3.626497 |
| 138 43 23.9 | 318 38 11.6 | Wickford | 16542.5 | 4.218602 |
| 202 42 20.5 | 22 43 22.9 | Miantonomy. | 5659.5 | 3.752775 |
| 202 38 03.4 | 22 39 05.8 | Miantonomy | 5674.9 | 3.753957 |
| 178 04 18.5 | 358 04 18.5 | Telegraph. | 17.0 | 1.229518 |
| 31 55 58.6 | 211 51 27.3 | McSparran | 17933.0 | 4.253654 |
| 307 30 33.8 | 127 34 04.6 | Quaker. | 9270.7 | 3.967114 |
| 337 51 03.2 | 157 52 39.0 | Telegraph 2 | 8902.0 | 3.949488 |
| 298 29 46.6 | 118 32 24.9 | Miantonomy. | 6301.2 | 3.799420 |
| 303 44 25.8 | 123 45 42.8 | Telegraph 2 | 3243.6 | 3.511027 |
| 234 50 19.3 | 54 52 38.7 | Miantonomy. | 5968.3 | 3.775849 |
| 234 50 20.2 | 54 52 39.6 | Miantonomy | 5969.0 | 3.775899 |
| 104 26 59.1 | 284 23 29.1 | McSparran. | 7590.2 | 3.880253 |
| 235 50 41.0 | 55 53 52.0 | Hull | 8070.9 | 3.906923 |
| 284 35 32.5 | 104 39 02.2 | Dumplin 2. | 7588.1 | 3.880150 |
| 36 44 41.2 | 216 43 24.1 | McSparran 2 | 4507.2 | 3.653906 |
| 257 02 09.1 | 77 04 03.1 | Hull. | 4088.3 | 3.611543 |
| 137 49 26.9 | 317 47 11.3 | McSparran | 7074.4 | 3.849691 |
| 85 56 27.0 | 265 53 25.7 | Meeting-house Hill 2. | 6376.0 | 3.804547 |
| 359 27 15.2 | 179 27 18.1 | Miantonomy | 10649.6 | 4.027335 |
| 299 02 03.2 | 119 04 18.3 | Quaker. | 5390.8 | 3.731653 |
| 334 27 45.0 | 154 30 06.1 | Batty | 11429.0 | 4.058008 |
| 6 46 35.5 | 186 45 45.1 | McSparran. | 14931.3 | 4.174096 |
| 257 35 29.7 | 77 39 22.8 | Prudence | 8324.8 | 3.920374 |
| 335 27 35.8 | 155 28 53.7 | Batty. | 6556.5 | 3.816672 |
| 12 56 44.6 | 192 56 01.5 | Barber's Heights | 6715.9 | 3.827105 |
| 336 13 28.8 | 156 14 39.8 | Hull. | 6150.9 | 3.788937 |
| 266 06 36.5 | 86 09 25.5 | Quaker | 5911.8 | 3.771717 |
| 100 35 43.4 | 280 32 23.8 | Quonsett. | 7086.6 | 3.850438 |
| 119 24 25.1 | 299 23 03.2 | Quonsett 3 | 3279.2 | 3.515766 |
| 41 29 16.6 | 221 27 11.7 | Barber's Heights. | 6587.3 | 3.818707 |
| 82 00 34.1 | 261 51 40.3 | Tiff | 18888.0 | 4.276186 |
| 34 00 07.0 | 213 49 06.0 | Block Island. | 41721.0 | 4.620355 |
| 342 42 37.5 | 162 43 38.9 | Quaker | 7208.4 | 3.857842 |
| 225 39 19.2 | 45 40 55.4 | Mount Hope 2. | 4681.3 | 3.670366 |
| 338 47 41.3 | 158 48 26.8 | Quaker | 4386.6 | 3.642125 |
| 43 14 04.9 | 223 09 59.8 | Hull. | 12500.8 | 4.096938 |
| 98 15 10.1 | 278 13 53.7 | Hull | 2697.7 | 3.430991 |
| 312 26 08.3 | 132 27 30.3 | Miantonomy. | 3884.5 | 3.589335 |

**NARRAGANSETT BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Hall's (Ben) house, west chimney. | 41 35 08.267 | 255.0 | 71 16 414.328 | 957.3 |
| Prudence Island light-house. 1869. | 41 36 28.93 | 892.6 | 71 18 30.35 | 702.7 |
| Teft's house, chimney. | 41 28 01.34 | 41.3 | 71 27 37.94 | 880.4 |
| Watson's house, chimney. | 41 28 22.37 | 690.2 | 71 26 05.70 | 132.3 |
| Barn, west gable. | 41 28 35.10 | 1082.8 | 71 23 28.36 | 657.9 |
| Potter's (Dr.) house, chimney. | 41 27 00.95 | 29.3 | 71 26 30.46 | 707.0 |
| Potter's (And.) house, chimney. | 41 30 29.90 | 922.5 | 71 21 38.60 | 895.1 |
| Newport, Ocean house. | 41 28 53.24 | 1642.5 | 71 18 30.59 | 709.7 |
| Newport, Catholic church spire. | 41 28 49.06 | 1513.5 | 71 18 49.38 | 1145.6 |
| Newport, Belmont's house, cupola. | 41 27 52.17 | 1709.5 | 71 18 22.46 | 521.1 |
| Newport, Bronson's house, flagstaff. | 41 27 51.76 | 1596.8 | 71 21 28.23 | 655.0 |
| Rose Island, flagstaff. | 41 29 47.52 | 1466.0 | 71 20 34.30 | 795.4 |
| Fort Adams, flagstaff. 1869. | 41 28 45.88 | 1415.4 | 71 20 20.25 | 469.7 |
| Anderson's barn, cupola. | 41 33 41.31 | 1274.4 | 71 17 23.46 | 543.5 |
| Portsmouth Grove, flagstaff. | 41 35 13.03 | 401.9 | 71 17 13.73 | 318.0 |
| West. | 41 38 44.42 | 1370.4 | 71 15 42.00 | 972.0 |
| Pappoose Squaw 2. 1861. | 41 39 15.20 | 468.9 | 71 18 02.45 | 56.7 |
| Hog Island 2. 1861. | 41 38 40.48 | 1248.8 | 71 16 50.79 | 1175.4 |
| Bristol, Methodist church. | 41 40 15.39 | 474.8 | 71 16 31.88 | 737.5 |
| Quonsett 2. 1863. | 41 35 16.90 | 521.4 | 71 24 23.02 | 533.2 |
| Calf Pasture Point. | 41 37 40.62 | 1253.1 | 71 24 18.99 | 439.6 |
| Warwick light-house. 1863. | 41 40 01.43 | 44.1 | 71 22 43.28 | 1001.3 |
| Sandy Point. | 41 39 43.29 | 1335.5 | 71 24 37.14 | 859.2 |

**NARRAGANSETT BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 279 54 26.2 | 99 55 21.3 | Quaker | 1951.5 | 3.290379 |
| 129 17 10.8 | 309 15 50.8 | Prudence 2. | 3604.5 | 3.556849 |
| 0 52 02 | 180 51 57 | Miantonomy | 10856.7 | 4.03570 |
| 302 24 02 | 122 26 09 | Quaker. | 5268.0 | 3.72164 |
| 28 09 39 | 208 09 02 | Meeting-house Hill 2 | 2735.3 | 3.43700 |
| 185 29 03 | 5 29 12 | McSparran 2. | 3298.8 | 3.51836 |
| 48 17 04 | 228 15 26 | Meetinghouse Hill 2 | 4597.7 | 3.66254 |
| 262 33 03 | 82 35 41 | Dumplin 2. | 5566.0 | 3.74554 |
| 64 02 17 | 243 58 55 | Meeting-house Hill 2 | 7879.8 | 3.89651 |
| 260 04 23 | 80 05 16 | Dumplin 2. | 1896.7 | 3.27800 |
| 242 02 42 | 62 05 36 | Dumplin 2 | 6898.4 | 3.83875 |
| 166 21 04 | 346 20 28 | McSparran 2. | 5296.5 | 3.72399 |
| 11 54 48 | 191 54 29 | Dumplin 2 | 3285.5 | 3.51660 |
| 338 04 42 | 158 05 40 | Telegraph 2. | 5407.6 | 3.73300 |
| 49 02 56 | 229 01 49 | Telegraph 2 | 3404.1 | 3.49193 |
| 177 09 47 | 357 09 42 | Miantonomy. | 3206.6 | 3.50604 |
| 140 20 05 | 320 17 35 | Hull | 8238.1 | 3.91583 |
| 184 45 22 | 45 30 | Miantonomy. | 3342.7 | 3.52417 |
| 221 30 10 | 41 31 54 | Paradise Rock | 5493.8 | 3.73987 |
| 107 32 35 | 287 30 06 | Dumplin 2. | 5483.9 | 3.73909 |
| 217 50 02 | 37 51 55 | Miantonomy | 6457.8 | 3.81008 |
| 151 05 47 | 331 05 21 | Dumplin 2. | 1900.7 | 3.27890 |
| 240 34 35 | 60 35 52 | Miantonomy | 3111.6 | 3.49298 |
| 48 41 34 | 228 40 32 | Dumplin 2. | 2889.0 | 3.46074 |
| 89 52 52 | 269 51 41 | Dumplin 2 | 2496.2 | 3.39727 |
| 353 40 19 | 173 40 25 | Telegraph 2. | 1818.8 | 3.25978 |
| 159 55 33 | 339 54 41 | Prudence | 5285.7 | 3.72310 |
| 69 45 51 | 249 42 24 | Hull. | 7727.2 | 3.88802 |
| 53 38 50 | 233 35 16 | Hull | 9282.3 | 3.96765 |
| 136 18 37 | 316 17 39 | Prudence 2. | 2952.6 | 3.47021 |
| 78 44 54 | 258 41 39 | Pine Hill | 6933.8 | 3.84097 |
| 209 11 34 | 29 12 24 | Mount Hope. | 3594.7 | 3.55566 |
| 286 16 34 | 106 18 07 | West | 3385.9 | 3.52967 |
| 246 21 21 | 66 23 45 | Mount Hope. | 5460.3 | 3.73722 |
| 122 51 55 | 302 51 07 | Pappoose Squaw 2 | 1974.1 | 3.29536 |
| 225 43 54 | 45 45 30 | Mount Hope. | 4670.4 | 3.66935 |
| 263 29 11 | 83 30 35 | Mount Hope | 2925.7 | 3.46623 |
| 350 09 00 | 170 09 49 | Quaker. | 9957.7 | 3.99816 |
| 226 10 12 | 46 12 43 | Pine Hill | 7289.9 | 3.86272 |
| 299 21 34 | 119 22 56 | Conanicut H. | 3273.2 | 3.51497 |
| 263 13 13 | 83 15 41 | Pine Hill | 5202.2 | 3.71619 |
| 335 26 26 | 155 27 45 | Conanicut N. | 6639.6 | 3.82214 |
| 321 39 47 | 141 41 12 | Pine Hill | 4757.0 | 3.67733 |
| 27 01 20 | 207 00 16 | Calf Pasture Point. | 4876.2 | 3.68808 |
| 257 59 47 | 78 01 03 | Warwick light-house, 1863 | 2692.8 | 3.43020 |
| 353 40 00 | 173 40 12 | Calf Pasture. | 3807.9 | 3.58068 |

**NARRAGANSETT BAY—Continued.**

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Green's Point. | 41 41 03.60 | 111.1 | 71 24 43.18 | 998.6 |
| Hope Island, barn. | 41 36 09.97 | 307.6 | 71 22 00.42 | 9.7 |
| Buttonwood house, cupola. | 41 41 19.12 | 589.9 | 71 25 58.28 | 1347.8 |
| Yellow barn, cupola. | 41 41 01.77 | 54.6 | 71 27 13.58 | 314.1 |
| White house, north chimney. | 41 40 46.09 | 1421.9 | 71 27 04.36 | 100.8 |
| North Popasquash. | 41 40 54.61 | 1684.8 | 71 18 12.28 | 284.0 |
| Nayatt light-house. 1863. | 41 43 30.64 | 945.3 | 71 20 21.88 | 505.7 |
| Rocky Point. | 41 41 29.72 | 916.9 | 71 21 50.06 | 1157.6 |
| Pappoose Squaw. | 41 39 15.20 | 468.9 | 71 18 02.52 | 58.3 |
| Rumstick. | 41 42 24.05 | 742.0 | 71 18 07.76 | 179.4 |
| Connimicut. | 41 43 01.67 | 51.5 | 71 21 29.44 | 680.5 |
| Babcock. | 41 42 44.36 | 1368.5 | 71 18 24.80 | 573.3 |
| Hall. | 41 43 12.06 | 372.1 | 71 17 05.59 | 129.2 |
| Rocky Point Hotel, chimney. | 41 41 21.91 | 675.9 | 71 21 56.52 | 1307.0 |
| Barn, white cupola. | 41 42 22.66 | 699.1 | 71 16 55.43 | 1281.5 |
| Warren Beacon. 1863. | 41 42 48.74 | 1503.7 | 71 17 37.24 | 860.9 |
| Warren, Methodist spire. | 41 43 48.78 | 1504.9 | 71 17 02.72 | 62.9 |
| Yellow house, west chimney. | 41 43 41.87 | 1291.7 | 71 19 23.20 | 536.2 |
| Warwick light-house. 1843. | 41 40 01.44 | 44.4 | 71 22 43.33 | 1002.4 |
| Warwick Neck. | 41 41 21.10 | 650.9 | 71 22 49.72 | 1149.8 |
| Warwick Beacon. 1843. | 41 39 25.02 | 771.9 | 71 23 36.17 | 836.9 |
| Nayatt light-house. 1843. | 41 43 30.09 | 928.3 | 71 20 22.31 | 515.6 |
| Hope Island. | 41 36 10.30 | 317.8 | 71 21 59.62 | 1380.6 |

**NARRAGANSETT BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 304 39 24 | 124 40 44 | Warwick light-house, 1863 | 3372.0 | 3.52789 |
| 356 46 12 | 176 46 16 | Sandy Point. | 2481.5 | 3.39472 |
| 7 54 34 | 187 54 21 | Conanicut N | 3273.9 | 3.51506 |
| 131 05 36 | 311 04 04 | Calf Pasture Point. | 4256.0 | 3.62900 |
| 297 58 12 | 118 00 22 | Warwick light-house, 1863 | 5107.6 | 3.70822 |
| 327 35 03 | 147 35 57 | Sandy Point. | 3501.9 | 3.54430 |
| 269 03 32 | 89 05 12 | Green's Point | 3479.2 | 3.54148 |
| 303 46 08 | 123 47 52 | Sandy Point. | 4354.3 | 3.63892 |
| 260 35 38 | 80 37 12 | Green's Point | 3309.6 | 3.51978 |
| 299 37 17 | 119 38 55 | Sandy Point. | 3918.1 | 3.59308 |
| 31 44 02 | 211 42 27 | Pine Hill | 6316.0 | 3.80044 |
| 75 21 32 | 255 18 32 | Warwick light-house, 1863. | 6479.8 | 3.81156 |
| 328 05 13 | 148 06 39 | North Popasquash | 5670.2 | 3.75360 |
| 1 48 45 | 181 48 36 | Pine Hill. | 10191.3 | 4.00823 |
| 280 46 43 | 100 51 38 | Mount Hope | 10451.5 | 4.01918 |
| 323 07 45 | 143 12 05 | Quaker. | 15122.7 | 4.17963 |
| 334 26 35 | 154 28 25 | Quaker | 8815.8 | 3.94526 |
| 246 21 44 | 66 24 08 | Mount Hope. | 5461.7 | 3.73733 |
| 344 06 08 | 164 08 01 | Quaker | 14327.2 | 4.15616 |
| 22 51 08 | 202 49 30 | Pine Hill. | 8823.5 | 3.94564 |
| 240 12 58 | 60 13 43 | Nayatt light-house, 1863 | 1799.2 | 3.25508 |
| 310 40 30 | 130 42 41 | North Popasquash. | 6012.6 | 3.77906 |
| 355 06 38 | 175 06 46 | North Popasquash | 3398.3 | 3.53126 |
| 97 09 07 | 277 07 04 | Connimicut. | 4301.5 | 3.63362 |
| 19 59 16 | 199 58 32 | North Popasquash | 4512.3 | 3.65440 |
| 64 59 00 | 244 58 07 | Babcock. | 2020.8 | 3.30552 |
| 208 50 37 | 28 51 40 | Nayatt light house, 1863 | 4534.4 | 3.65652 |
| 279 12 17 | 99 14 46 | North Popasquash. | 5254.1 | 3.72058 |
| 107 57 24 | 287 56 25 | Babcock | 2171.9 | 3.33683 |
| 171 14 25 | 351 14 18 | Hall. | 1542.1 | 3.18810 |
| 12 57 44 | 192 57 21 | North Popasquash | 3613.1 | 3.55788 |
| 82 59 53 | 262 59 21 | Babcock. | 1107.8 | 3.04448 |
| 16 40 04 | 196 39 18 | North Popasquash | 5608.9 | 3.74888 |
| 83 05 13 | 263 03 00 | Nayatt light-house, 1863. | 4636.8 | 3.66622 |
| 342 21 51 | 162 22 38 | North Popasquash | 5414.5 | 3.73356 |
| 75 40 26 | 255 39 47 | Nayatt light-house, 1863. | 1399.6 | 3.14601 |
| 266 09 57 | 86 15 28 | Mount Hope | 11525.0 | 4.06164 |
| 312 16 52 | 132 21 48 | Quaker. | 13932.2 | 4.14402 |
| 278 14 24 | 98 19 59 | Mount Hope | 11768.7 | 4.07073 |
| 34 58 26 | 214 56 14 | High Rocks. | 8038.4 | 3.90517 |
| 261 31 15 | 81 37 21 | Mount Hope | 12862.0 | 4.10931 |
| 16 33 28 | 196 30 56 | McSparran. | 18603.3 | 4.26959 |
| 335 59 58 | 156 03 20 | Quaker | 17311.3 | 4.23833 |
| 60 37 47 | 240 33 10 | Whitman. | 11069.8 | 4.04414 |
| 233 00 40 | 53 05 41 | Mount Hope | 13130.8 | 4.11829 |
| 283 34 10 | 103 38 36 | Quaker. | 9562.7 | 3.98058 |

**NARRAGANSETT BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Pojack. | 41 39 04.92 | 151.8 | 71 24 27.97 | 647.2 |
| Warren Spire. | 41 43 48.47 | 1495.3 | 71 17 04.14 | 95.7 |
| Bristol court-house. | 41 40 12.66 | 390.6 | 71 16 25.67 | 593.8 |
| Wickford Spire. | 41 34 23.40 | 721.9 | 71 27 00.02 | 0.5 |
| Wickford light-house. 1843. | 41 34 15.92 | 491.1 | 71 26 22.64 | 524.6 |
| Patience. | 41 39 33.47 | 1032.6 | 71 21 24.58 | 568.7 |
| Apponaug spire. | 41 41 55.84 | 1722.7 | 71 27 30.08 | 695.6 |
| Hog Island. | 41 38 40.38 | 1245.7 | 71 16 50.58 | 1170.4 |
| Castle Island Beacon. 1843. | 41 39 13.97 | 431.0 | 71 17 12.20 | 282.3 |
| Castle Hill. | 41 27 53.02 | 1635.7 | 71 21 28.80 | 668.3 |
| Fox Island. | 41 33 16.24 | 501.0 | 71 25 04.48 | 103.8 |
| Dyer's Island. | 41 34 57.25 | 1766.2 | 71 17 55.49 | 1285.4 |
| Goat Island light-house. 1843. | 41 29 36.09 | 1113.4 | 71 19 39.10 | 907.0 |
| Poorhouse belfry. | 41 30 26.86 | 828.6 | 71 19 43.31 | 1006.5 |
| Fort Adams, flagstaff. 1843. | 41 28 47.51 | 1465.7 | 71 20 14.24 | 330.4 |
| Gould Island. | 41 32 04.30 | 132.7 | 71 20 42.02 | 974.1 |
| South Rock. | 41 34 26.66 | 822.5 | 71 25 03.67 | 85.0 |
| Halfway Rock. | 41 33 49.82 | 1537.0 | 71 19 58.34 | 1351.8 |
| Beavertail light-house. 1839–'43. | 41 26 56.86 | 1754.2 | 71 23 59.42 | 1379.3 |
| Rose Island. | 41 29 48.20 | 1487.0 | 71 20 34.44 | 798.8 |
| Prince. | 41 44 34.61 | 1067.7 | 71 18 56.22 | 1299.0 |
| Reynolds. | 41 33 45.55 | 1405.2 | 71 26 52.10 | 1207.2 |
| Sherman's house, chimney. | 41 33 47.42 | 1462.9 | 71 22 24.25 | 561.9 |

**NARRAGANSETT BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 124 42 23 | 304 40 29 | Whitman | 4822.5 | 3.68327 |
| 259 44 36 | 79 51 16 | Mount Hope. | 14145.6 | 4.15062 |
| 29 04 31 | 208 57 39 | McSparran | 29688.6 | 4.47259 |
| 67 13 21 | 247 06 32 | Whitman. | 15469.6 | 4.18948 |
| 261 26 23 | 81 27 42 | Mount Hope | 2794.5 | 3.44630 |
| 350 53 24 | 170 54 09 | Quaker. | 9851.0 | 3.99348 |
| 3 50 43 | 183 50 27 | McSparran | 8547.9 | 3.93186 |
| 266 14 46 | 86 22 32 | Quaker. | 16289.2 | 4.21190 |
| 9 50 54 | 189 50 13 | McSparran | 8421.5 | 3.92539 |
| 101 01 23 | 281 00 17 | Wickford. | 2361.6 | 3.37320 |
| 260 25 56 | 80 30 34 | Mount Hope | 9813.9 | 3.99184 |
| 315 05 56 | 135 10 00 | Quaker. | 12018.2 | 4.07984 |
| 307 15 07 | 127 23 13 | Quaker | 21294.6 | 4.32827 |
| 354 23 59 | 174 24 06 | Whitman. | 2540.4 | 3.40491 |
| 225 39 21 | 45 40 57 | Mount Hope | 4668.7 | 3.66920 |
| 342 44 59 | 162 46 00 | Quaker. | 7203.4 | 3.85754 |
| 341 34 39 | 161 35 55 | Quaker | 8343.1 | 3.92133 |
| 239 52 35 | 59 54 26 | Mount Hope. | 4438.0 | 3.64719 |
| 113 05 22 | 293 01 26 | McSparran | 8975.1 | 3.95304 |
| 252 57 27 | 72 58 54 | Hazard. | 3184.5 | 3.50304 |
| 119 03 13 | 299 01 14 | Wickford | 4723.0 | 3.67422 |
| 228 02 03 | 48 09 07 | Mount Hope. | 19856.4 | 4.29790 |
| 52 09 12 | 232 06 06 | Batty | 8241.2 | 3.91599 |
| 205 30 08 | 35 32 27 | Mount Hope. | 11243.7 | 4.05091 |
| 217 14 33 | 37 15 14 | Miantonomy | 2362.9 | 3.37344 |
| 347 28 32 | 167 28 46 | Hazard. | 2301.8 | 3.36206 |
| 258 21 59 | 78 22 43 | Miantonomy | 1559.8 | 3.19306 |
| 351 06 14 | 171 06 31 | Hazard. | 3859.9 | 3.58658 |
| 213 35 44 | 33 36 48 | Miantonomy | 4057.6 | 3.60827 |
| 299 38 44 | 119 39 22 | Hazard. | 1512.7 | 3.17976 |
| 199 00 42 | 19 02 01 | Prudence | 8488.5 | 3.92883 |
| 265 28 01 | 85 31 08 | Slate. | 6566.0 | 3.81730 |
| 320 17 23 | 140 19 01 | Batty | 5349.5 | 3.72831 |
| 20 46 04 | 200 44 30 | McSparran. | 9227.8 | 3.96510 |
| 50 51 37 | 230 49 52 | Batty | 4718.6 | 3.67381 |
| 342 29 29 | 162 30 23 | Miantonomy. | 6235.8 | 3.79489 |
| 86 49 38 | 266 46 36 | Meeting-house Hill | 6382.2 | 3.80497 |
| 137 46 58 | 317 44 42 | McSparran. | 7087.6 | 3.85050 |
| 89 48 21 | 269 43 49 | McSparran | 9517.0 | 3.97850 |
| 325 46 02 | 145 46 53 | Hazard. | 3169.6 | 3.50100 |
| 320 49 12 | 140 52 11 | Mount Hope | 9886.0 | 3.99502 |
| 57 29 25 | 237 23 50 | Whitman. | 13800.7 | 4.13990 |
| 230 41 46 | 50 43 25 | Quonsett 3 | 4457.0 | 3.64904 |
| 295 18 28 | 115 21 18 | Hull. | 6560.8 | 3.81696 |
| 135 06 06 | 315 04 47 | Quonsett 3 | 3903.2 | 3.59142 |
| 5 32 04 | 185 31 56 | Hull. | 2878.3 | 3.45913 |

**NARRAGANSETT BAY**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| School-house, chimney. | 41 32 18.25 | 563.0 | 71 22 33.32 | 772.3 |
| Barn, cupola. | 41 32 08.72 | 269.0 | 71 22 36.98 | 857.3 |
| Dutch Island, flagstaff. 1868. | 41 30 19.30 | 595.4 | 71 24 04.75 | 110.2 |
| Potter's windmill, shaft. | 41 30 56.30 | 1736.9 | 71 22 28.66 | 664.6 |
| Dutch Island light-house. 1868. | 41 29 48.28 | 1489.5 | 71 24 17.18 | 398.5 |
| Narragansett church. | 41 29 33.60 | 1036.6 | 71 25 33.46 | 776.2 |
| Tefft's barn, cupola. | 41 31 32.92 | 1015.6 | 71 25 34.92 | 809.6 |
| Hamilton Mills, cupola. | 41 32 57.49 | 1773.6 | 71 26 17.05 | 395.2 |
| Sanford's Mill, cupola. | 41 33 05.93 | 182.9 | 71 26 53.50 | 1239.9 |
| Fox Island, house chimney. | 41 33 15.00 | 462.8 | 71 25 06.59 | 152.7 |
| Wickford Academy. | 41 34 06.68 | 206.1 | 71 27 21.19 | 491.0 |
| Wickford Baptist church. | 41 34 19.58 | 604.1 | 71 27 05.35 | 123.9 |
| Fish House, chimney. | 41 34 41.97 | 1294.8 | 71 26 51.84 | 1200.9 |
| Smith's barn, cupola. | 41 36 00.02 | 0.6 | 71 25 23.04 | 533.6 |
| Wickford light-house. 1868. | 41 34 15.92 | 491.1 | 71 26 22.59 | 523.4 |
| Green's barn, cupola. | 41 33 42.34 | 1306.2 | 71 26 31.25 | 724.1 |
| Vaughn's house, cupola. | 41 34 25.62 | 790.4 | 71 27 45.68 | 1058.3 |
| Poor-house, northeast gable. | 41 35 21.98 | 678.1 | 71 24 50.76 | 1175.7 |
| Browning's house, chimney. | 41 32 00.82 | 25.3 | 71 25 49.54 | 1148.5 |
| Signal flag. | 41 35 32.16 | 992.1 | 71 25 42.20 | 977.4 |
| Boston Neck. | 41 28 19.08 | 588.6 | 71 26 05.43 | 126.0 |
| Prudence Island light-house. 1861. | 41 36 21.34 | 658.4 | 71 18 14.46 | 334.9 |

**NARRAGANSETT BAY**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 75 45 15 | 255 43 19 | Barber's Heights | 4180.6 | 3.62124 |
| 155 13 53 | 335 12 40 | Quonsett 3. | 6074.9 | 3.78354 |
| 79 30 36 | 259 28 42 | Barber's Heights | 4034.6 | 3.60580 |
| 157 03 00 | 337 01 50 | Quonsett 3. | 6309.6 | 3.80000 |
| 177 20 11 | 357 19 59 | Quonsett 3 | 9195.2 | 3.96356 |
| 209 59 14 | 30 00 13 | Hull. | 4105.6 | 3.61338 |
| 109 49 26 | 289 47 27 | Barber's Heights | 4422.1 | 3.64563 |
| 175 50 38 | 355 50 33 | Hull. | 2420.9 | 3.38398 |
| 155 26 14 | 335 25 27 | Barber's Heights | 3955.1 | 3.59716 |
| 179 12 45 | 359 12 41 | Quonsett 3. | 10143.3 | 4.00618 |
| 188 43 54 | 8 44 41 | Quonsett 3 | 10719.4 | 4.03017 |
| 219 35 48 | 39 37 45 | Hull. | 6446.0 | 3.80929 |
| 193 30 36 | 13 31 24 | Quonsett 3 | 7110.8 | 3.85192 |
| 252 45 20 | 72 47 19 | Hull. | 4337.4 | 3.63723 |
| 211 29 20 | 31 30 36 | Quonsett 3 | 5048.7 | 3.70318 |
| 284 29 18 | 104 31 45 | Hull. | 5287.3 | 3.72323 |
| 284 51 32 | 104 54 23 | Hull | 6169.9 | 3.79028 |
| 321 37 44 | 141 38 41 | Barber's Heights. | 3189.3 | 3.50370 |
| 194 56 35 | 14 57 04 | Quonsett 3 | 3896.8 | 3.59071 |
| 298 07 55 | 118 09 35 | Hull. | 3952.6 | 3.59688 |
| 242 13 18 | 62 15 16 | Quonsett 3 | 4659.9 | 3.66838 |
| 297 36 11 | 117 40 20 | Hull. | 7454.9 | 3.87244 |
| 244 43 24 | 64 45 12 | Quonsett 3 | 4153.2 | 3.61838 |
| 301 42 22 | 121 45 21 | Hull. | 7333.1 | 3.86529 |
| 274 46 00 | 94 49 01 | Conanicut N | 6323.1 | 3.80093 |
| 0 11 52 | 180 11 52 | Reynolds. | 1740.4 | 3.24066 |
| 304 39 57 | 124 41 59 | Conanicut N | 5159.6 | 3.71262 |
| 26 26 51 | 206 25 52 | Reynolds. | 4633.0 | 3.66586 |
| 235 42 35 | 55 43 54 | Quonsett 3 | 3347.1 | 3.52467 |
| 267 10 18 | 87 12 59 | Conanicut N. | 5630.2 | 3.75052 |
| 225 25 42 | 45 27 07 | Quonsett 3 | 4163.3 | 3.61944 |
| 337 59 53 | 158 00 35 | Barber's Heights. | 3908.4 | 3.59200 |
| 251 17 51 | 71 20 05 | Quonsett 3 | 4951.5 | 3.69474 |
| 327 14 46 | 147 16 17 | Barber's Heights. | 5895.9 | 3.77055 |
| 283 26 44 | 103 27 02 | Quonsett 3 | 656.4 | 2.81719 |
| 331 39 21 | 151 40 50 | Hull. | 6568.7 | 3.81748 |
| 198 16 53 | 18 17 50 | Quonsett 3 | 6375.6 | 3.80452 |
| 314 41 45 | 134 41 59 | Barber's Heights. | 699.4 | 2.84471 |
| 293 52 23 | 113 54 37 | Conanicut N | 5126.1 | 3.70979 |
| 357 19 52 | 177 20 01 | Barber's Heights. | 7019.6 | 3.84631 |
| 145 50 35 | 325 49 43 | McSparran | 3276.2 | 3.51537 |
| 50 00 19 | 229 58 41 | Meeting-house Hill. | 4499.5 | 3.65317 |
| 214 57 09 | 34 59 40 | Mount Hope | 9216.2 | 3.96455 |
| 302 24 05 | 122 26 02 | Quaker. | 4832.1 | 3.68414 |

RHODE ISLAND AND MASSACHUSETTS BOUNDARY.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Beaconpole (Borden). | 42 00 03.257 | 100.5 | 71 26 43.159 | 993.2 |
| Red Brush, Massachusetts (C. & G. S. and Borden). | 42 01 49.546 | 1528.7 | 71 22 23.459 | 539.6 |
| Joe's Rock, Massachusetts (Borden). | 42 01 52.99 | 1634.9 | 71 24 17.24 | 396.6 |
| Great Rock, Massachusetts (C. & G. S. and Borden). | 41 51 32.36 | 998.4 | 71 17 15.47 | 356.8 |
| King's Rock, Massachusetts (Borden). | 41 45 22.81 | 704.0 | 71 16 17.27 | 399.0 |
| Munroe (Borden). | 41 46 34.35 | 1059.8 | 71 19 05.61 | 129.6 |
| Burnt Swamp, Massachusetts (Borden). | 42 01 08.36 | 257.9 | 71 22 54.53 | 1254.6 |
| Bald Hill Massachusetts (Borden). | 42 02 44.22 | 1364.3 | 71 42 35.59 | 818.4 |
| Alumpond, Massachusetts, (Borden). | 42 01 14.51 | 447.7 | 71 45 45.24 | 1040.8 |
| Mount Daniel, Massachusetts (Borden). | 42 01 41.54 | 1281.6 | 71 48 10.30 | 236.9 |
| Northwest corner of Rhode Island (Borden). | 42 00 29.15 | 899.4 | 71 47 58.92 | 1355.8 |
| Northeast corner of Connecticut (Borden). | 42 01 24.82 | 765.8 | 71 48 04.20 | 96.6 |

FROM POINT JUDITH TO KNAPP'S POINT.

| | | | | |
|---|---|---|---|---|
| Wilcox. | 41 21 23.198 | 715.5 | 71 43 59.859 | 1391.4 |
| Green Hill. | 41 22 24.700 | 762.0 | 71 35 51.593 | 1199.0 |
| Peleg Tiff. | 41 23 18.746 | 578.4 | 71 48 40.418 | 939.0 |
| Noyes' Point. | 41 19 46.309 | 1428.7 | 71 45 19.443 | 452.0 |
| Cranberry Hill. | 41 20 53.226 | 1642.1 | 71 47 22.770 | 529.3 |
| Joshua Champlin. | 41 22 16.387 | 505.6 | 71 39 55.332 | 1285.8 |
| Tiff. | 41 27 48.562 | 1498.2 | 71 32 15.700 | 364.3 |
| Meeting-house Hill. | 41 26 45.316 | 1398.0 | 71 28 33.931 | 787.5 |
| Austin. | 41 24 25.282 | 780.0 | 71 28 44.899 | 1042.9 |
| Weeden. | 41 22 50.890 | 1570.0 | 71 33 15.241 | 354.4 |
| Point Judith. | 41 21 54.836 | 1691.8 | 71 29 17.941 | 417.0 |

RHODE ISLAND AND MASSACHUSETTS BOUNDARY.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | Metres. | |
| 305 28 55.0 | 125 38 03.8 | Great Meadow | 23244.3 | 4.366316 |
| 348 15 00.0 | 168 16 48.8 | College Hill. | 18415.5 | 4.265183 |
| 322 22 16.3 | 142 28 31.5 | Great Meadow | 21193.4 | 4.326202 |
| 58 30 07.5 | 238 27 01.6 | Beaconpole. | 7498.8 | 3.874993 |
| 317 20 11 | 137 27 42 | Great Meadow | 22963.8 | 4.361044 |
| 358 58 34 | 178 58 45 | College Hill. | 21420.4 | 4.330828 |
| 19 20 33 | 199 13 48 | McSparran | 42668.3 | 4.630105 |
| 354 56 55 | 174 58 13 | Quaker. | 30816.3 | 4.488780 |
| 198 13 55 | 18 16 05 | Great Meadow | 14369.1 | 4.157430 |
| 130 32 00 | 310 26 51 | College Hill. | 14066.5 | 4.148187 |
| 322 36 12 | 142 41 14 | Pocasset | 17267.9 | 4.237240 |
| 346 14 23 | 166 16 54 | Quaker. | 22136.4 | 4.345107 |
| 125 54 18 | 305 53 23 | Joe's Rock | 2348.4 | 3.370766 |
| 209 20 39 | 29 21 00 | Red Brush. | 1458.0 | 3.163751 |
| 282 40 55 | 102 51 37 | Beaconpole (Borden) | 22466.8 | 4.351541 |
| 274 40 34 | 94 53 18 | Beaconpole (Borden) | 26372.0 | 4.421144 |
| 237 35 26 | 57 37 37 | Bald Hill. | 5166.4 | 3.713189 |
| 255 51 38 | 75 55 31 | Bald Hill | 7935.5 | 3.899574 |
| 284 01 11 | 104 02 48 | Alumpond. | 3438.3 | 3.536350 |
| 173 17 09 | 353 17 01 | Mount Daniel | 2248.8 | 3.351960 |
| 275 40 05 | 95 41 38 | Alumpond | 3211.9 | 3.50676 |
| 164 50 30 | 344 50 26 | Mount Daniel. | 534.4 | 2.72786 |

FROM POINT JUDITH TO KNAPP'S POINT.

| | | | | |
|---|---|---|---|---|
| 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 |
| 358 43 39.4 | 178 43 53.2 | Block Island | 21989.3 | 4.342211 |
| 80 33 10.8 | 260 27 48.1 | Wilcox. | 11505.8 | 4.060917 |
| 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 |
| 144 32 11.7 | 324 29 58.9 | Peleg Tiff | 8048.2 | 3.905700 |
| 211 45 12.8 | 31 46 05.4 | Wilcox. | 3515.3 | 3.545962 |
| 258 53 31.3 | 78 55 45.4 | Wilcox | 4806.8 | 3.681858 |
| 158 06 29.8 | 338 05 38.5 | Peleg Tiff. | 4838.4 | 3.684705 |
| 344 08 44.7 | 164 11 39.3 | Block Island | 22583.9 | 4.353799 |
| 58 27 35.9 | 238 24 01.7 | Noyes' Point. | 8843.5 | 3.946623 |
| 97 40 25.0 | 277 30 47.4 | Champlin | 20413.3 | 4.309913 |
| 8 05 19.3 | 188 03 10.6 | Block Island. | 32295.0 | 4.509135 |
| 110 46 50.4 | 290 44 23.6 | Tiff | 5504.7 | 3.740734 |
| 61 41 38.0 | 241 38 13.6 | Broad Hill. | 8148.6 | 3.911083 |
| 183 22 22.4 | 3 22 29.7 | Meeting-house Hill | 4327.6 | 3.636248 |
| 93 46 11.1 | 273 42 54.0 | Broad Hill. | 6934.5 | 3.841015 |
| 169 13 01.9 | 349 12 43.7 | Broad Hill | 3425.1 | 3.534672 |
| 245 05 59.4 | 65 08 58.1 | Austin. | 6922.6 | 3.840270 |
| 189 23 18.8 | 9 23 40.6 | Austin | 4704.3 | 3.672496 |
| 107 25 57.0 | 287 23 20.1 | Weeden. | 5779.4 | 3.761880 |

**FROM POINT JUDITH TO KNAPP'S POINT**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Point Judith light-house, 1838. | 41 21 39.884 | 1230.4 | 71 28 54.732 | 1272.1 |
| Sherman. | 41 30 16.938 | 522.6 | 71 30 56.024 | 1299.2 |
| Wilbur. | 41 29 29.630 | 914.1 | 71 38 32.536 | 754.7 |
| Shannock. | 41 28 05.190 | 160.1 | 71 38 21.488 | 498.6 |
| Kingston church spire, 1838–'69. | 41 28 48.900 | 1508.6 | 71 31 33.541 | 778.1 |
| Pawkhungernock church. | 41 30 20.058 | 618.8 | 71 50 25.464 | 590.5 |
| Block Island North light-house, 1838. | 41 13 29.152 | 899.4 | 71 34 33.050 | 769.8 |
| Watch Hill light-house, 1838. | 41 18 13.695 | 422.5 | 71 51 32.255 | 750.4 |
| Quonochontaug. | 41 19 59.986 | 1850.7 | 71 42 37.329 | 867.9 |
| Meetinghouse Hill 2. 1869. | 41 26 43.175 | 1332.0 | 71 28 33.552 | 778.8 |
| New Weeden. | 41 22 54.286 | 1674.7 | 71 33 16.313 | 379.1 |
| Governor's Island. | 41 21 19.416 | 599.0 | 71 39 12.292 | 285.7 |
| Kenyon. | 41 23 25.332 | 781.5 | 71 37 01.430 | 33.2 |
| Ajax. | 41 20 35.864 | 1106.4 | 71 41 17.404 | 404.6 |
| Bunker Hill. | 41 23 10.163 | 313.5 | 71 39 16.346 | 379.8 |
| Hiscox. | 41 21 29.185 | 900.3 | 71 42 14.556 | 338.3 |
| Noyes' Neck. | 41 19 46.490 | 1434.2 | 71 45 19.841 | 461.4 |
| Commons. | 41 21 15.213 | 469.2 | 71 43 54.697 | 1271.4 |
| Village Hill. | 41 20 54.173 | 1671.3 | 71 44 59.291 | 1378.3 |
| Hector. | 41 19 31.659 | 976.7 | 71 47 20.571 | 478.4 |
| Cranberry Hill 2. 1873. | 41 20 53.397 | 1647.3 | 71 47 22.799 | 530.0 |
| Achilles. | 41 19 15.355 | 473.7 | 71 48 47.545 | 1105.8 |
| Fort Hill. | 41 20 01.266 | 39.1 | 71 49 15.129 | 351.8 |

FROM POINT JUDITH TO KNAPP'S POINT—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 80 35 18.7 | 260 20 32.0 | Watch Hill | 31652.2 | 4.500403 |
| 187 54 33.3 | 7 55 32.8 | McSparran. | 15170.7 | 4.181007 |
| 20 26 23.0 | 200 24 32.6 | Broad Hill | 11093.4 | 4.045066 |
| 85 13 12.8 | 265 02 42.2 | Champlin. | 22155.9 | 4.345490 |
| 87 56 57.6 | 267 51 29.5 | Champlin | 11495.9 | 4.060544 |
| 323 00 45.7 | 143 03 57.5 | Broad Hill. | 11184.1 | 4.048600 |
| 100 34 53.0 | 280 29 17.6 | Champlin | 11948.0 | 4.077295 |
| 273 25 29.1 | 93 29 31.3 | Tiff. | 8504.1 | 3.929627 |
| 51 38 32.4 | 231 30 18.7 | Wilcox | 22123.6 | 4.344855 |
| 92 20 29.7 | 272 10 24.1 | Champlin. | 21226.2 | 4.326872 |
| 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 |
| 113 02 21.8 | 292 51 19.4 | Watch Hill | 25381.3 | 4.404514 |
| 13 48 28.3 | 193 47 50.4 | Block Island. | 5625.0 | 3.750121 |
| 197 23 37.0 | 17 23 46.9 | Watch Hill | 1171.5 | 3.068736 |
| 302 21 57.4 | 122 32 31.3 | Block Island. | 26537.2 | 4.423855 |
| 244 37 59.8 | 64 42 27.9 | Green Hill | 10435.1 | 4.018497 |
| 330 24 24.8 | 150 29 06.2 | Block Island. | 20139.9 | 4.304057 |
| 247 04 21.6 | 67 08 37.0 | Dumplin 2 | 9716.8 | 3.987524 |
| 195 44 21.8 | 15 45 07.6 | McSparran 2. | 5917.4 | 3.772130 |
| 75 49 09.6 | 255 47 27.0 | Green Hill | 3722.0 | 3.570778 |
| 169 18 15.0 | 349 17 57.5 | Broad Hill. | 3317.5 | 3.520814 |
| 246 37 45.6 | 66 39 58.2 | Green Hill | 5081.0 | 3.705945 |
| 62 48 52.1 | 242 46 36.7 | Quonochontaug. | 5359.9 | 3.729159 |
| 319 03 00.1 | 139 03 46.3 | Green Hill | 2476.3 | 3.393801 |
| 38 04 10.2 | 218 02 43.7 | Governor's Island. | 4933.3 | 3.693142 |
| 245 11 43.1 | 65 13 05.8 | Governor's Island | 3203.9 | 3.505679 |
| 59 13 46.8 | 239 12 54.0 | Quonochontaug. | 2163.0 | 3.335061 |
| 261 29 48.8 | 81 31 18.0 | Kenyon | 3169.3 | 3.500969 |
| 286 24 21.1 | 106 26 36.4 | Green Hill. | 4960.2 | 3.695502 |
| 274 03 07.5 | 94 05 07.9 | Governor's Island | 4247.4 | 3.628128 |
| 10 53 36.2 | 190 53 21.2 | Quonochontaug. | 2802.2 | 3.447503 |
| 263 41 53.3 | 83 43 40.6 | Quonochontaug | 3801.9 | 3.580004 |
| 78 10 36.7 | 258 06 40.8 | Watch Hill. | 8492.5 | 3.929034 |
| 35 53 04.6 | 215 52 08.4 | Noyes' Neck | 3377.9 | 3.528653 |
| 322 12 49.6 | 142 13 40.7 | Quonochontaug. | 2936.2 | 3.467788 |
| 296 50 48.4 | 116 52 22.2 | Quonochontaug | 3699.9 | 3.568188 |
| 12 53 29.0 | 192 53 15.4 | Noyes' Neck. | 2142.0 | 3.330816 |
| 260 44 01.1 | 80 45 20.8 | Noyes' Neck | 2844.7 | 3.454031 |
| 76 51 26.6 | 256 48 50.4 | Watch Hill. | 5652.1 | 3.752212 |
| 269 34 32.9 | 89 36 07.7 | Village Hill | 3336.4 | 3.523274 |
| 358 49 22.1 | 178 49 23.6 | Hector. | 2522.1 | 3.401765 |
| 258 44 04.7 | 78 46 21.9 | Noyes' Neck | 4925.0 | 3.692405 |
| 77 18 58.3 | 257 17 19.5 | Watch Hill. | 3568.1 | 3.552439 |
| 288 54 49.8 | 108 56 05.4 | Hector | 2816.2 | 3.449669 |
| 52 13 49.6 | 232 12 29.0 | Watch Hill. | 3592.0 | 3.555339 |

**FROM POINT JUDITH TO KNAPP'S POINT**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Frost, Connecticut. | 41 20 57.572 | 1776.0 | 71 51 03.250 | 75.6 |
| Watch Hill light-house, 1873–'86. | 41 18 14.192 | 437.8 | 71 51 32.432 | 754.6 |
| Eel's Hill 2, Connecticut. 1838. | 41 22 49.868 | 1538.4 | 71 51 04.352 | 101.1 |
| Montauk 2, New York. 1874. | 41 03 54.383 | 1677.7 | 71 54 18.505 | 432.0 |
| Paine. | 41 09 18.853 | 581.6 | 71 33 44.990 | 1049.0 |
| Block Island north light-house, 1874. | 41 13 39.660 | 1223.4 | 71 34 34.736 | 809.1 |
| Block Island (southeast) light-house, 1875. | 41 09 10.120 | 312.2 | 71 33 08.391 | 195.6 |
| James. | 41 32 41.81 | 1289.8 | 71 39 52.97 | 1227.6 |
| Bushy Hill. | 41 12 43.99 | 1357.0 | 71 33 40.56 | 944.9 |
| Tower Hill church. | 41 28 02.85 | 87.9 | 71 27 35.23 | 817.5 |
| Big Hill. | 41 23 26.36 | 813.3 | 71 46 08.49 | 197.3 |
| Wells' Hill. | 41 25 56.65 | 1747.7 | 71 45 15.92 | 369.6 |
| Diamond Hill, tree. | 41 25 46.62 | 1438.3 | 71 46 28.73 | 667.0 |
| Cormorant Hill. | 41 23 37.22 | 1148.2 | 71 49 03.45 | 80.2 |
| Sugar Loaf Hill. | 41 26 04.96 | 153.1 | 71 30 40.02 | 929.1 |
| Wakefield flagstaff. | 41 26 05.03 | 155.1 | 71 30 40.05 | 929.9 |
| Wakefield church, white spire. | 41 26 24.25 | 748.2 | 71 30 11.06 | 256.7 |
| Wakefield church, gray spire | 41 26 25.58 | 789.2 | 71 29 50.95 | 1182.8 |
| Peirce's barn, cupola. | 41 25 34.08 | 1051.4 | 71 28 50.74 | 1178.1 |
| Block Island, derrick. | 41 09 10.01 | 308.8 | 71 33 08.80 | 205.2 |
| Sandhill. | 41 21 40.62 | 1253.2 | 71 42 17.39 | 404.2 |
| White house, west chimney. | 41 23 20.46 | 631.2 | 71 29 18.66 | 433.6 |
| Sherman's (J. P.) house, center chimney. | 41 23 25.18 | 776.8 | 71 31 45.62 | 1059.9 |

**FROM POINT JUDITH TO KNAPP'S POINT**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 304 38 01.8 | 124 39 13.2 | Fort Hill | 3055.6 | 3.485095 |
| 4 42 40.8 | 184 42 31.6 | Watch Hill. | 3951.0 | 3.596705 |
| 187 39 57.9 | 7 40 17.3 | Frost | 5085.7 | 3.706351 |
| 224 01 10.6 | 44 02 41.4 | Fort Hill. | 4594.5 | 3.662237 |
| 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 |
| 188 40 43.8 | 8 42 43.2 | Watch Hill | 27947.9 | 4.446349 |
| 244 53 56.6 | 65 06 18.3 | Block Island. | 29031.3 | 4.462867 |
| 70 56 10.1 | 250 42 39.1 | Montauk 2 | 30471.9 | 4.483899 |
| 132 31 57.8 | 312 30 48.2 | Block Island. | 3342.1 | 3.524013 |
| 56 55 18.4 | 236 42 19.5 | Montauk 2 | 32985.2 | 4.518320 |
| 12 41 29.9 | 192 40 53.1 | Block Island. | 5931.6 | 3.773168 |
| 71 55 20.9 | 251 41 25.9 | Montauk 2 | 31195.1 | 4.494086 |
| 127 19 59.9 | 307 18 26.3 | Block Island. | 4170.2 | 3.620162 |
| 56 36 34 | 236 31 59 | Champlin | 11525.2 | 4.06165 |
| 15 19 54 | 195 17 11 | Wilcox. | 21705.5 | 4.33657 |
| 114 45 02 | 294 33 25 | Watch Hill | 27063.9 | 4.43239 |
| 32 14 10 | 212 12 58 | Block Island. | 4810.3 | 3.68217 |
| 86 09 06 | 266 06 00 | Tiff | 6523.6 | 3.81449 |
| 18 52 41 | 198 47 27 | Block Island. | 34250.0 | 4.53466 |
| 86 12 36 | 266 10 56 | Peleg Tiff | 3537.6 | 3.54871 |
| 20 04 51 | 200 04 02 | Cranberry Hill. | 5029.7 | 3.70154 |
| 44 17 46 | 224 15 31 | Peleg Tiff | 6803.5 | 3.83273 |
| 14 45 32 | 194 44 57 | Big Hill. | 4794.4 | 3.68073 |
| 33 51 20 | 213 49 53 | Peleg Tiff | 5492.2 | 3.73975 |
| 353 47 56 | 173 48 09 | Big Hill. | 4352.3 | 3.63872 |
| 62 32 10 | 242 30 50 | Eel's Hill 2 | 3166.3 | 3.50055 |
| 316 47 47 | 136 48 02 | Peleg Tiff. | 781.7 | 2.89303 |
| 248 06 52 | 68 08 16 | Meetinghouse Hill 2 | 3163.8 | 3.50021 |
| 213 25 47 | 33 27 56 | McSparran 2. | 8238.4 | 3.91584 |
| 213 29 16 | 33 31 25 | McSparran | 8210.8 | 3.91438 |
| 246 59 19 | 67 00 42 | Meetinghouse Hill. | 3180.7 | 3.50253 |
| 255 31 45 | 75 32 50 | Meetinghouse Hill 2 | 2337.8 | 3.36881 |
| 48 29 45 | 228 29 26 | Sugar Loaf Hill. | 897.7 | 2.95312 |
| 253 11 03 | 73 11 54 | Meetinghouse Hill 2 | 1877.0 | 3.27347 |
| 60 49 58 | 240 49 26 | Sugar Loaf Hill. | 1304.7 | 3.11550 |
| 190 36 17 | 10 36 28 | Meetinghouse Hill 2 | 2168.5 | 3.33615 |
| 110 35 24 | 290 34 12 | Sugar Loaf Hill. | 2710.3 | 3.43302 |
| 71 55 22 | 251 41 26 | Montauk 2 | 31184.6 | 4.49394 |
| 127 27 07 | 307 25 34 | Block Island. | 4164.6 | 3.61957 |
| 77 17 45 | 257 16 37 | Wilcox | 2441.7 | 3.38770 |
| 8 29 52 | 188 29 39 | Quonochontaug. | 3138.8 | 3.49676 |
| 79 21 55 | 259 17 35 | Green Hill | 9291.2 | 3.96807 |
| 111 48 21 | 291 45 26 | Broad Hill. | 6608.6 | 3.82011 |
| 65 40 25 | 245 39 25 | New Weeden | 2312.8 | 3.36413 |
| 130 17 05 | 310 15 48 | Broad Hill. | 3568.5 | 3.55248 |

**FROM POINT JUDITH TO KNAPP'S POINT**—Continued.

| Station. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Topographical pole 4. | 41 23 59.28 | 1828.8 | 71 32 40.78 | 947.3 |
| Hazard's (A. P.) house, center chimney. | 41 24 34.68 | 1069.9 | 71 33 04.20 | 97.6 |
| Topographical pole 6. | 41 24 00.68 | 21.0 | 71 33 31.32 | 727.5 |
| Browning's (W. T.) house, center chimney. | 41 23 12.44 | 383.8 | 71 34 36.28 | 843.0 |
| Topographical pole 3. | 41 23 17.94 | 553.4 | 71 35 17.72 | 411.7 |
| Topographical pole, near post-road. | 41 23 41.82 | 1290.1 | 71 35 54.60 | 1268.5 |
| Seventh-Day meeting house, north chimney. | 41 23 36.04 | 1111.8 | 71 36 30.00 | 697.0 |
| Kenyon's (H. G.) house, center chimney. | 41 22 56.41 | 1740.2 | 71 37 06.67 | 155.0 |
| Liberty pole. | 41 21 41.54 | 1281.5 | 71 37 21.90 | 509.0 |
| Border Hill, topographical pole. | 41 23 26.74 | 824.9 | 71 38 29.70 | 690.0 |
| Yellow barn, cupola. | 41 22 31.40 | 968.7 | 71 37 26.60 | 618.1 |
| Harris' barn, east cupola. | 41 22 19.74 | 609.0 | 71 40 22.64 | 526.1 |
| Westerly. | 41 21 59.88 | 1847.3 | 71 40 52.84 | 1228.1 |
| Davis' (O.) house, east gable chimney. | 41 20 56.91 | 1755.6 | 71 44 09.26 | 215.3 |
| Brown's (E.) house, chimney. | 41 19 54.22 | 1672.7 | 71 45 25.62 | 595.8 |
| Bentley. | 41 21 51.91 | 1601.4 | 71 45 33.28 | 773.4 |
| Nye's (R.) house, white chimney. | 41 21 54.53 | 1682.3 | 71 46 28.12 | 653.5 |
| Knapp's Point, house chimney. | 41 18 22.53 | 695.1 | 71 53 07.63 | 177.5 |
| Dunn's house, white chimney. | 41 21 06.38 | 196.8 | 71 46 07.44 | 172.9 |
| Sanders' (E.) house, chimney. | 41 20 26.32 | 812.0 | 71 44 46.60 | 1083.4 |
| Hazard's Castle. | 41 24 55.10 | 1699.9 | 71 27 28.37 | 658.9 |
| Wharton's (Dr.) house, east chimney. | 41 24 56.65 | 1747.7 | 71 27 16.49 | 382.9 |

**FROM POINT JUDITH TO KNAPP'S POINT**—Continued.

| Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|
| ° ′ ″ | ° ′ ″ | | *Metres.* | |
| 56 40 03 | 236 37 57 | Green Hill | 5307.4 | 3.72488 |
| 131 03 14 | 311 02 33 | Broad Hill. | 1910.9 | 3.28124 |
| 5 11 36 | 185 11 28 | New Weeden | 3109.8 | 3.49273 |
| 44 08 23 | 224 06 32 | Green Hill. | 5586.0 | 3.74710 |
| 47 45 24 | 227 43 51 | Green Hill | 4403.3 | 3.64378 |
| 167 34 08 | 347 34 00 | Broad Hill. | 1240.7 | 3.09366 |
| 49 55 28 | 229 54 38 | Green Hill | 2287.3 | 3.35933 |
| 96 44 20 | 276 42 44 | Kenyon. | 3395.8 | 3.53094 |
| 25 36 20 | 205 35 58 | Green Hill | 1821.5 | 3.26042 |
| 95 24 41 | 275 23 32 | Kenyon. | 2420.3 | 3.38387 |
| 358 19 03 | 178 19 05 | Green Hill | 2380.2 | 3.37662 |
| 71 51 46 | 251 51 02 | Kenyon. | 1633.8 | 3.21321 |
| 337 55 14 | 157 55 39 | Green Hill | 2374.9 | 3.37564 |
| 65 39 56 | 245 39 35 | Kenyon. | 801.3 | 2.90379 |
| 187 46 28 | 7 46 31 | Kenyon | 900.3 | 2.95441 |
| 299 16 37 | 119 17 27 | Green Hill. | 2000.3 | 3.30109 |
| 188 27 01 | 8 27 15 | Kenyon | 3237.1 | 3.51016 |
| 237 36 11 | 57 37 11 | Green Hill. | 2485.7 | 3.39544 |
| 271 12 12 | 91 13 10 | Kenyon | 2051.6 | 3.31209 |
| 297 30 02 | 117 31 47 | Green Hill. | 4142.5 | 3.61726 |
| 199 21 47 | 19 22 04 | Kenyon | 1763.6 | 3.24639 |
| 275 20 24 | 95 21 27 | Green Hill. | 2217.4 | 3.34585 |
| 318 41 14 | 138 42 00 | Governor's Island | 2477.1 | 3.39394 |
| 21 40 20 | 201 39 44 | Ajax. | 3447.9 | 3.53756 |
| 298 05 41 | 118 06 47 | Governor's Island | 2649.5 | 3.42317 |
| 12 25 04 | 192 24 48 | Ajax. | 2653.9 | 3.42389 |
| 249 30 46 | 69 32 02 | Hiscox | 2846.3 | 3.45428 |
| 309 23 50 | 129 24 51 | Quonochontaug. | 2766.4 | 3.44191 |
| 236 34 37 | 56 36 43 | Hiscox | 5321.1 | 3.72600 |
| 267 22 57 | 87 24 48 | Quonochontaug. | 3917.2 | 3.59297 |
| 336 04 48 | 156 05 10 | Village Hill | 1948.4 | 3.28968 |
| 54 40 27 | 234 39 15 | Cranberry Hill 2. | 3120.8 | 3.49427 |
| 312 01 50 | 132 02 49 | Village Hill | 2780.4 | 3.44410 |
| 33 58 57 | 213 58 21 | Cranberry Hill 2. | 2274.0 | 3.35679 |
| 211 09 07 | 31 10 29 | Frost | 5589.6 | 3.74738 |
| 251 46 20 | 71 47 33 | Watch Hill. | 2704.3 | 3.43206 |
| 209 28 58 | 29 29 21 | Bentley | 1613.5 | 3.20776 |
| 283 22 00 | 103 22 45 | Village Hill. | 1628.4 | 3.21176 |
| 218 38 47 | 38 39 21 | Commons | 1931.7 | 3.28595 |
| 285 06 31 | 105 07 56 | Quonochontaug. | 3113.5 | 3.49325 |
| 115 51 31 | 295 49 24 | Sugar Loaf Hill | 4944.6 | 3.69413 |
| 226 15 27 | 46 18 59 | Dumplin 2. | 10294.1 | 4.01259 |
| 151 26 12 | 331 25 21 | Meeting-house Hill 2 | 3741.7 | 3.57306 |
| 178 50 11 | 358 50 06 | McSparran 2. | 8983.2 | 3.95343 |

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# APPENDIX No. 9.

RESULTS DEDUCED FROM THE GEODETIC CONNECTION OF THE YOLO BASE LINE WITH THE PRIMARY TRIANGULATION OF CALIFORNIA. ALSO A REDUCTION AND ADJUSTMENT OF THE DAVIDSON QUADRILATERALS FORMING PART OF THAT TRIANGULATION.

By CHARLES A. SCHOTT, Assistant.

PREFATORY NOTE.

In this paper on the results of higher geodesy as applied to the primary triangulation of California, Assistant Schott has given a full exposition of the method employed on the Survey for the computation of triangulation of the first order, and a more complete explanation than has heretofore been presented of the manner in which weights are applied to observed directions.

Appendix No. 14, Report for 1864, gives an account of the method as then introduced by Mr. Schott and used by him for discussing the results of the geodetic connection of the Epping base with the primary triangulation of the New England States.

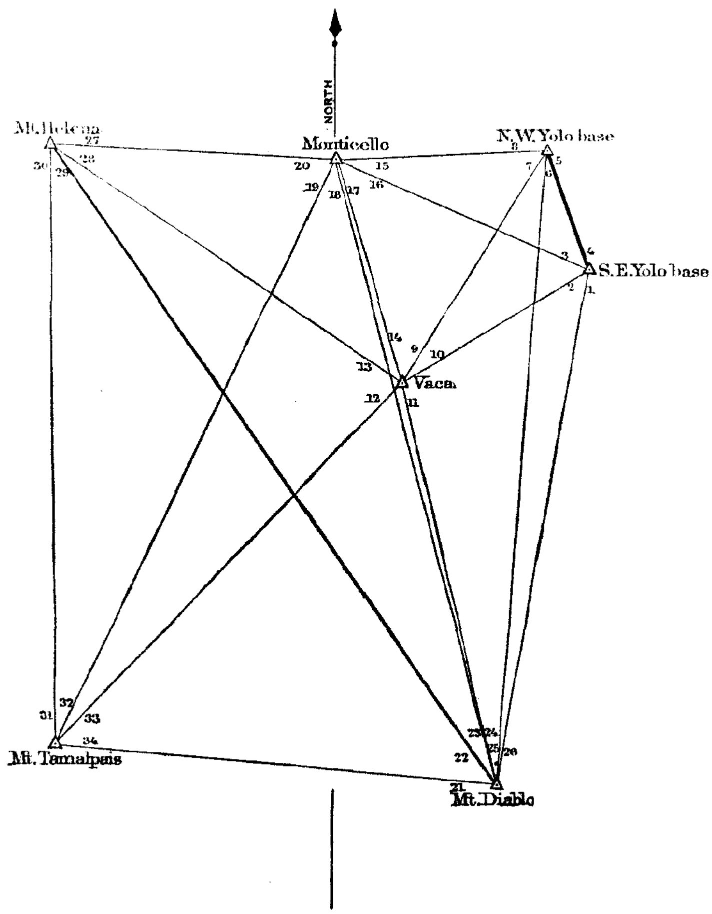
In the paper now presented two new steps are introduced not believed to have been hitherto taken in any triangulation, viz, the introduction of a correction to latitudes for curvature of the vertical, and the reduction of horizontal directions to the sea-level of the station observed upon. These reductions required a knowledge of the heights of the stations already given in Appendix No. 10, Report for 1884. The introduction of these refinements was justified by the magnitude and accuracy of the work.

COMPUTING DIVISION,
COAST AND GEODETIC SURVEY OFFICE,
*December* 31, 1885.

Up to the present time the geographical positions on the charts published by the Survey of the region about San Francisco depended upon two preliminary base lines, measured respectively in 1851 and 1853, and upon a series of triangles covering the immediate coast line. This work was executed principally by the late Assistant R. D. Cutts. When later it became necessary to provide for a more comprehensive scheme of triangulation, which was not only to satisfy the requirements of the western coast but also to form a part of that grander scheme of the geodetic connection of the surveys of the Atlantic and Pacific coasts, the western part of the work was placed in charge of Assistant George Davidson, under whom it has been prosecuted from 1876 to the present time. In December, 1884, the field-work was so far complete as to admit of the introduction of the primary base line measured by him in 1881 in Yolo County, in the valley of the Sacramento River, and to compute and adjust that part of the triangulation known as the Davidson quadrilaterals, also to connect the same with this base and introduce the astronomical determinations, so as to form standard geodetic data to answer for the main and subordinate triangulations of California, as well as for its extension across Nevada into Utah. It is proposed to give a tolerably complete account of the computations, in view of the importance of the work, and to take this opportunity of exhibiting the method adopted by the Survey in dealing with the reduction of first-class field-work, possessing an accuracy and magnitude not surpassed anywhere. It is, however, with that step only which effects the ascent from the base to the first primary line that we are here chiefly concerned.

Referring to plate No. 16 of this Report, entitled "Progress of the Transcontinental Triangulation," it is intended to deduce the length and probable error of the primary side "Mount Helena to Mount Diablo," California, as derived from the Yolo base-measure and from the angular measures at the connecting triangulation points, and which it is the immediate object of our paper to exhibit; next, to do the same for the primary side "Mount Nebo–Tushar," Utah, as derived from the Utah Valley base (as yet unmeasured); and finally to compute or adjust as a whole the primary triangulation intervening between these sides and stretching over California across Nevada to the middle of Utah, a distance but little short of 600 statute miles (or about 950 kilometres), from Mount Helena, California, to Mount Nebo, Utah.

The accompanying figure was taken from the plate referred to, and shows that the connection of the base with the primary side is made through a well-shaped or well-conditioned figure decomposable into several quadrilaterals, and having a compact area with Vaca as a central station. The length of the base* is, roughly, 10$\frac{3}{4}$ statute miles, or about 17$\frac{1}{2}$ kilometres, and the length of the primary side is nearly 67 statute miles, or 107$\frac{3}{4}$ kilometres. Every one of the trigonometrical points is an astronomical station for latitude and azimuth, as are also the adjacent primary stations, Mount Lola and Round Top.




Two theodolites were used in the measure of the horizontal directions; diameters of graduation, 20 inches (50 cm.). They are provided with three reading microscopes, and have an eye-piece micrometer for repeating the pointings in connection with the same circle reading. The horizontal circle was used in twenty-three positions, and ordinarily between two and three series were taken in each position of the circle, each series consisting of pointings and readings of each object in succession and in the direction of increasing circle readings, with reversal of the telescope (the same pivot remaining in contact with the same Y it rested on before reversal), and followed by similar successive observations of the objects in a direction the *reverse* of that first used. After the several ocular pointings were reduced to a mean value and the circle readings were corrected for run of screw of microscopes, the measures of the various series were adjusted to give the most probable values of the several directions, together with their probable errors. This station or local adjustment was made in accordance with Bessel's method developed in his "Gradmessung," published in 1838, but stopping short at the point where the local weight-equations are formed, which it

*See Appendix No. 11, Coast and Geodetic Survey Report for 1883.

was not proposed to carry over to the general figure adjustment—an essential difference presently again to be referred to. An account of the local adjustment of observed directions is given in Appendix No. 33, Coast Survey Report for 1854, pages 71–76, and in many later works;* hence there appears to be no need for repeating it here. The probable error of a single measure of a direction (*i. e.*, the mean value derived from series, telescope direct, motion forward, and series telescope reversed, motion backward) is found by

$$e_1 = \sqrt{\frac{0.455\ \Sigma\triangle^2}{n - s - d + 1}}$$

where $\Sigma\triangle^2 =$ the sum of squares of differences,† $n =$ number of observations, $s =$ number of series, and $d =$ number of directions. The probable error of a resulting direction is

$$\varepsilon_1 = \sqrt{\frac{0.455\ \Sigma\triangle^2}{(s-1)\ (\text{diagonal coefficient})}}$$

All the pointings were on heliotropes. To the following abstract of resulting directions and their probable errors at each station, there has been added a further correction for elevation of the observed object above the sea horizon, and due to the non-intersection of the verticals in the same point of the axis of the spheroid; this correction‡ is: $\frac{e^2}{2} \cdot \frac{h}{R} \sin 2\ \alpha \cos^2 \varphi$, where $e^2 = \frac{a^2 - b^2}{a^2}$, $h =$ the elevation of the observed point, $R =$ the radius of curvature in the plane perpendicular to the meridian, $\varphi =$ the latitude of the station occupied, and $\alpha =$ the azimuth of the line of sight counted from south in the direction of west to 360°. For the Clarke spheroid of 1866 and the vicinity of the parallel of 39° we have $\log e^2 = \bar{7}.8305$ and $\log R = 6.8054$, and dividing the expression by $\sin 1''$ we have with sufficient accuracy the correction in seconds $0''.000109 \sin 2\alpha \cos^2 \varphi . h$, where $h$ is expressed in metres; hence, finally, $0''.000066 \sin 2\alpha . h$. The heights of the stations are given in Appendix No. 10, Coast and Geodetic Survey Report for 1884.

*Abstract of the horizontal directions resulting from the local adjustment at each of the stations composing the Yolo base-net of triangulation.*§

SOUTHEAST BASE. Occupied in 1880 with theodolite No. 115. G. Davidson, observer.

| Object. | Resulting direction. | Probable error. | Reduction to sea-level. | Resulting seconds. |
|---|---|---|---|---|
| | ° ′ ″ | ″ | ″ | ″ |
| Northwest base. | 0 00 00.000 | ±0.043 | −.002 | 59.998 |
| Marysville Butte. | 15 32 39.320 | .085 | −.002 | 39.318 |
| Pine Hill. | 89 51 47.540 | .069 | +.023 | 47.563 |
| Mount Diablo. | 204 49 35.777 | .085 | +.021 | 35.798 |
| Vaca. | 252 41 55.204 | .079 | +.045 | 55.249 |
| Monticello. | 310 54 36.564 | .074 | −.046 | 36.518 |

* For instance: T. W. Wright's Treatise on the Adjustment of Observations, New York, 1884, Article 146; Dr. W. Jordan's Vermessungskunde, 1878, Vol. II, § 38; Col. Clarke's Geodesy, Oxford, 1880, Chapter IX, Article 8.

† See Coast Survey Report for 1864, App. No. 14, pp. 120–123. In the formulæ (p. 122) for the probable error of a *resulting* direction the substitution of $s - 1$ for $s$ will give a more correct value.

‡ See for instance Clarke's Geodesy, p. 113, and Jordan's Geodesy, Vol. II, p. 317.

§ These abstracts include some directions to secondary objects which entered into the adjustment, but they omit all subordinate directions as irrelevant to the present purpose.

*Abstract of the horizontal directions resulting from the local adjustment at each of the stations composing the Yolo base-net of triangulation—Continued.*

NORTHWEST BASE. Occupied in 1880 with theodolite No. 115. G Davidson, observer.

| Object. | Resulting direction. | Probable error. | Reduction to sea-level. | Resulting seconds. |
|---|---|---|---|---|
| | ° ′ ″ | ″ | ″ | ″ |
| Southeast base. | 0 00 00.000 | ±0.038 | −.001 | $\overline{59}$.999 |
| Mount Diablo. | 20 04 24.623 | .080 | +.008 | 24.631 |
| Vaca. | 47 20 34.153 | .067 | +.042 | 34.195 |
| Monticello. | 103 42 21.384 | .059 | +.007 | 21.391 |
| Marysville Butte. | 200 07 47.730 | .075 | +.005 | 47.735 |
| Pine Hill. | 283 13 29.522 | .069 | +.005 | 29.527 |

VACA. Occupied in 1880 with theodolite No. 115. G. Davidson, observer.

| | | | | |
|---|---|---|---|---|
| Southeast base. | 0 00 00.000 | ±0.064 | +.001 | 00.001 |
| Pine Hill. | 12 12 58.103 | .080 | +.029 | 58.132 |
| Mount Diablo. | 109 03 23.738 | .083 | −.040 | 23.698 |
| Mount Tamalpais. | 166 20 42.497 | .107 | +.052 | 42.549 |
| Mount Helena. | 248 47 11.185 | .103 | −.082 | 11.103 |
| Monticello. | 288 18 44.230 | .108 | −.032 | 44.198 |
| Marysville Butte. | 318 15 04.533 | .098 | +.020 | 04.553 |
| Northwest base. | 334 38 38.711 | .073 | +.003 | 38.714 |

MONTICELLO. Occupied in 1880 with theodolite No. 115. G. Davidson, observer.

| | | | | |
|---|---|---|---|---|
| Mount Helena. | 0 00 00.000 | ±0.052 | −.003 | $\overline{59}$.997 |
| Marysville Butte. | 116 50 54.208 | .073 | +.035 | 54.243 |
| Pine Hill. | 175 09 43.409 | .053 | +.005 | 43.414 |
| Northwest base. | 175 30 36.288 | .051 | .000 | 36.288 |
| Southeast base. | 202 42 51.850 | .084 | −.001 | 51.849 |
| Vaca. | 252 48 57.254 | .066 | −.026 | 57.228 |
| Mount Diablo. | 253 17 07.113 | .107 | −.041 | 07.072 |
| Mount Tamalpais. | 292 27 41.105 | .062 | +.039 | 41.144 |

MOUNT DIABLO. Occupied in 1876 with theodolite No. 5. G. Davidson, observer. Re-occupied in 1884 with theodolite No. 115. R. A. Marr, observer (G. D., chief of party).

| | | | | |
|---|---|---|---|---|
| Mount Helena. | 0 00 00.000 | ±0.066 | −.082 | $\overline{59}$.918 |
| Monticello. | 20 03 30.643 | .090 | −.032 | 30.611 |
| Vaca. | 20 19 59.505 | .098 | −.024 | 59.481 |
| Azimuth mark. | 25 49 17.204 | { .092<br>.074† } | −.010 | 17.194 |
| Northwest base. | 38 39 09.129 | .115† | .000 | 09.129 |
| Marysville Butte. | 38 40 30.881 | .094 | +.005 | 30.886 |
| Southeast base. | 43 24 20.921 | .106† | .000 | 20.921 |

NOTE.—The directions marked by a † depend on the probable error ±″.074 of the azimuth mark during the second occupation.

*Abstract of the horizontal directions resulting from the local adjustment at each of the stations composing the Yolo base-net of triangulation—Continued.*

MOUNT DIABLO—Continued.

| Object. | Resulting direction. | Probable error. | Reduction to sea-level. | Resulting seconds. |
|---|---|---|---|---|
| | ° ′ ″ | ″ | ″ | ″ |
| Lola. | 73 06 31.834 | ±0.089 | +.178 | 32.012 |
| Pine Hill. | 76 14 00.524 | .106 | .041 | 00.565 |
| Round Top. | 97 32 04.551 | .107 | +.174 | 04.725 |
| Macho. | 180 16 12.207 | .111† | −.078 | 12.129 |
| Mount Bache or Loma Prieta. | 211 22 06.404 | .084† | ---- | ---- |
| Sierra Morena. | 249 16 39.858 | .092† | ---- | ---- |
| Mount Tamalpais. | 310 12 09.226 | .095 | −.008 | 09.218 |
| Ross Mountain. | 339 08 13.637 | .087† | ---- | ---- |

MOUNT HELENA. Occupied in 1876 with theodolite No. 5. G. Davidson and W. Eimbeck, observers.

| | | | | |
|---|---|---|---|---|
| Mount Diablo. | 0 00 00.000 | ±0.058 | −.073 | 59.927 |
| Mount Tamalpais. | 33 43 57.142 | .071 | −.004 | 57.138 |
| Snow Mountain, east. | 208 37 44.912 | .059 | ---- | ---- |
| Azimuth mark. | 225 16 49.643 | .052 | +.007 | 49.650 |
| Marysville Butte. | 265 31 14.523 | .078 | +.042 | 14.565 |
| Lola. | 281 54 43.341 | .083 | +.137 | 43.478 |
| Pine Hill. | 303 14 10.280 | .083 | +.004 | 10.284 |
| Round Top. | 305 18 41.177 | .074 | +.005 | 41.182 |
| Monticello. | 306 46 16.071 | .076 | −.002 | 16.069 |
| Vaca. | 340 03 44.142 | .113 | −.045 | 44.097 |

MOUNT TAMALPAIS. Occupied in 1882 with theodolite No. 115. G. Davidson, observer.

| | | | | |
|---|---|---|---|---|
| Mount Diablo. | 0 00 00.000 | ±0.053 | −.011 | 59.989 |
| Macho. | 23 47 56.302 | .064 | −.068 | 56.234 |
| Sierra Morena. | 61 37 29.923 | .076 | ---- | ---- |
| Ross Mountain. | 230 31 28.940 | .090 | ---- | ---- |
| Mount Helena. | 263 31 35.075 | .086 | −.006 | 35.069 |
| Monticello. | 289 01 42.852 | .072 | +.045 | 42.897 |
| Vaca. | 307 25 02.177 | .062 | +.048 | 02.225 |

LOLA.* Occupied in 1879 with theodolite No. 115. G. Davidson, observer.

| | | | | |
|---|---|---|---|---|
| Azimuth mark. | 0 00 00.000 | ±0.043 | −.157 | 59.843 |
| Lassen's Butte. | 13 22 42.494 | .113 | ---- | ---- |
| Pah-rah. | 114 46 59.230 | .074 | ---- | ---- |
| Mount Como. | 173 10 32.427 | .082 | ---- | ---- |
| Round Top. | 212 23 00.222 | .109 | −.137 | 00.085 |
| Pine Hill. | 267 17 07.756 | .084 | +.039 | 07.795 |
| Mount Diablo. | 271 17 55.376 | .059 | +.075 | 55.451 |
| Mount Helena. | 300 07 03.738 | .059 | +.062 | 03.800 |
| Marysville Butte. | 311 51 09.936 | .094 | +.016 | 09.952 |
| Snow Mountain, east. | 321 58 42.323 | .073 | ---- | ---- |
| Mount Linn. | 340 58 41.684 | .086 | ---- | ---- |

*This station was added to complete the resulting data for the Davidson quadrilaterals.

*Abstract of the horizontal directions resulting from the local adjustment at each of the stations composing the Yolo base-net of triangulation*—*Continued.*

ROUND TOP.* Occupied in 1879 with theodolite No. 115. G. Davidson, observer.

| Object. | Resulting direction. | Probable error. | Reduction to sea-level. | Resulting seconds. |
|---|---|---|---|---|
| | ° ′ ″ | ″ | ″ | ″ |
| Azimuth mark. | 0 00 00.000 | ±0.032 | —.159 | 59.841 |
| Lola. | 7 25 05.518 | .062 | —.119 | 05.399 |
| Mount Como. | 76 26 26.411 | .060 | ---- | ---- |
| Mount Grant. | 122 47 32.511 | .078 | ---- | ---- |
| Mount Conness. | 169 47 29.608 | .068 | ---- | ---- |
| Macho. | 254 03 23.038 | .053 | +.082 | 23.120 |
| Mount Diablo. | 270 44 49.863 | .051 | +.062 | 49.925 |
| Mount Helena. | 298 32 16.332 | .065 | —.003 | 16.329 |
| Pine Hill. | 301 58 42.947 | .061 | —.006 | 42.941 |
| Snow Mountain, east. | 316 57 47.335 | .047 | ---- | ---- |
| Marysville Butte. | 319 00 33.594 | .069 | —.029 | 33.565 |

* This station was added to complete the resulting data for the Davidson quadrilaterals.

Since the introduction (about 1847 or 1848) of the application of the method of least squares to the adjustment of the principal triangulations of the Survey, the *separate* treatment of the station adjustment from that of the figure or net adjustment has been adhered to. After the conditions subsisting between the measured directions at a station had been satisfied, these adjusted directions were simply introduced with *equal weight* in the net adjustment, the same as if they had been the direct result of observation. The method proposed by Bessel in 1838 of introducing the weight equations obtained in connection with the station adjustment into the figure adjustment, a process which complicates the reduction very considerably, has been generally followed without modification; others have preferred the more simple and, in our opinion, the better method followed by us which appears also to have been favored by Gauss, of keeping these processes separate. Our reasons for preferring the latter method (supplementing it, however, with the introduction of a special system of weights), and apart from its recommendation of greater simplicity, may be stated as follows: In the second operation or net adjustment *new* and *distinct* sources of error appear of a magnitude exceeding even the errors inherent in the first operation. It is almost the universal experience that the average corrections to the observed directions due to the net adjustment surpass in magnitude those due to the local adjustment, a fact which is explained by the presence of lateral refraction in the rays of light, the *constant* part of which deflection enters into the geometrical conditions of the net, and the *variable* part only becomes apparent in the station conditions. Besides the disturbing influence of lateral refraction, errors having their origin in the effect of local deviations of the vertical, imperfect centering of the theodolite or in slight eccentricity of the heliotrope, in outstanding systematic graduation errors of the circles, and in other causes, tend to increase the corrections needed in the geometrical treatment of the triangulation. To make these *second* corrections fully dependent on weights introduced from conditions only subsisting *locally* would seem to be of doubtful propriety; at any rate it would appear to be a sound principle to remove contradictions which had developed in observations constituting a distinct operation, and which depend on distinct sources of error, at once within the limits of that operation, and not to carry the conditions and weights into a second operation, which subjects the observed quantities to additional corrections, and which qualities depend on sources of error of a character and size different from those in the first operation. However correct the Besselian proceeding is from a theoretical point of view, there is, nevertheless, great danger that the results may be distorted by improper weights. At first, in Coast Survey practice, all directions in the net-adjustment were given equal weight, but in 1864 greater precision was attempted by the introduction of distinct weights depending mainly on the accuracy of the local measures, but not ignoring the new conditions arising from their combination in triangles and other figures; in short, the weights to the directions were made to consist of two parts, a variable one and a constant one, the latter to be furnished by means of the combination of triangles.

Investigations of the laws of lateral refraction hitherto made are mostly confined to short lines, and a valuable contribution to our knowledge of the subject may be expected from a discussion of our observations in connection with the great primary triangulation between California and Utah. An interesting discussion on the "Influence of lateral refraction on horizontal angles" was lately (1882) published by Dr. A. Fischer.* His general results may be summed up as follows:

The existence of lateral refraction as affecting the horizontal angular measures is proved directly and indirectly, the former by certain discrepancies in the observations, the latter by closing errors in the triangles or other figures; the influence of the distance of the observed object on the magnitude of the deviation is small; the higher the line of sight above the surface the smaller the lateral refraction may be expected to be. The principal factors determining the magnitude of the deviation are those depending on the condition of the atmosphere respecting distribution of density and temperature, both in a statical and in a dynamical sense. The lateral refraction appears to be subject to a daily variation, and he brings out the fact, from the triangulations of England and of Prussia, that the short lines are more seriously affected than the long ones, in consequence of their generally closer proximity to the ground and the consequent denser atmosphere, and recommends the *greatest* triangles possible.

With the largest triangles measurable there are the additional advantages of a smaller number of stations within a given area, and the greater accuracy with which the azimuth may be transferred from line to line. Should greater accuracy be demanded in the measures of horizonal directions than at present attained with our instruments, it may possibly be secured by a combination of day and night observations. This would eliminate the greater part of the effect which persists as a constant deviation during the time of insolation, but which lateral refraction may be supposed to change sign during the time of nocturnal radiation.

DETERMINATION OF WEIGHTS TO DIRECTIONS IN THE ADJUSTMENT OF THE TRIANGULATION.

By the process adopted in 1864 we require to know the relative magnitude of the observing errors (at a station) and of the combination (to triangles and polygons) errors, respectively. To this end we need the closing errors of the triangles, and consequently also a knowledge of the spherical excesses. For the computation of the length of sides of triangles we employ Legendre's theorem, extended, if required. It has been proved that spheroidal triangles, as well as spherical triangles, may be computed by means of this theorem without sensible error (Clarke's Geodesy Chapter V). It will make no difference whether the sides of the spheroidal triangle be conceived as elliptic arcs, as lines of alignment, or as geodetic lines. The following expression for the spherical excess $\varepsilon$ will apply to the largest triangles yet measured:

$$\varepsilon = \frac{a\,b \sin C'}{2\rho\,\rho_1 \sin 1''}\left[1 + \frac{1}{24\,r^2}(a^2 + b^2 + c^2)\right]$$

where $\rho =$ radius of curvature of the meridian and $\rho_1 =$ radius of curvature in the plane perpendicular to the meridian at a point situated at the center of the triangle. The sides $a$, $b$, $c$ are expressed in metres and the values of log $\rho$ and of log $\rho_1$ are tabulated in Appendix No. 18, Coast Survey Report for 1876. $C'$ is the plane angle of the triangle between the sides $a$ and $b$. The value of the first term is tabulated for the argument $\varphi$ (the latitude) in Appendix No. 7, Report for 1884. The second term, involving the square of the sides (and an average radius, $r$), seldom comes into use. Even in the largest triangle of the Survey, Mount Shasta, Mount Helena, Lola, whose sides are 133, 167, and 190 statute miles, respectively, or 214, 269, and 306 kilometres (nearly), the term involving the squares of the sides is but 0.00022, and when multiplied with the factor or first term, 142''.696, it becomes 0''.031; and in all cases it suffices to distribute the excess *equally* over the three angles.

* Prussian Geodetic Institute, Berlin.

*Table of closing errors of the triangles forming the Yolo base-figure, arranged in the order of the size of the triangles.*

| No. | Triangle. | Σ= sum of observed angles — π. | ε | Closing error. Σ−ε + | Σ−ε − |
|---|---|---|---|---|---|
| | | ″ | ″ | ″ | ″ |
| 1 | Mount Diablo, Monticello, Vaca. | —0.786 | 0.062 | ---- | 0.848 |
| 2 | Monticello, Northwest base, Southeast base. | +0.433 | 1.247 | ---- | 0.814 |
| 3 | Vaca, Northwest base, Southeast base. | 0.232 | 1.273 | ---- | 1.041 |
| 4 | Mount Diablo, Northwest base, Southeast base. | 0.624 | 1.350 | ---- | 0.726 |
| 5 | Monticello, Northwest base, Vaca. | 2.652 | 2.382 | 0.270 | ---- |
| 6 | Vaca, Monticello, Southeast base. | 2.451 | 2.408 | 0.043 | ---- |
| 7 | Mount Helena, Monticello, Vaca. | 3.892 | 3.113 | 0.779 | ---- |
| 8 | Mount Diablo, Vaca, Northwest base. | 4.196 | 4.018 | 0.178 | ---- |
| 9 | Mount Diablo, Vaca, Southeast base. | 4.588 | 4.095 | 0.493 | ---- |
| 10 | Mount Tamalpais, Monticello, Vaca. | 4.893 | 4.822 | 0.071 | ---- |
| 11 | Mount Diablo, Mount Helena, Vaca. | 2.798 | 5.401 | ---- | 2.603 |
| 12 | Mount Diablo, Monticello, Northwest base. | 6.062 | 6.463 | ---- | 0.401 |
| 13 | Mount Diablo, Monticello, Southeast base. | 6.253 | 6.566 | ---- | 0.313 |
| 14 | Mount Tamalpais, Mount Helena, Monticello. | 7.750 | 8.099 | ---- | 0.349 |
| 15 | Mount Diablo, Mount Tamalpais, Vaca. | 6.878 | 8.170 | ---- | 1.292 |
| 16 | Mount Diablo, Mount Helena, Monticello. | 7.476 | 8.452 | ---- | 0.976 |
| 17 | Mount Tamalpais, Mount Helena, Vaca. | 8.751 | 9.808 | --- | 1.057 |
| 18 | Mount Diablo, Mount Tamalpais, Mount Helena. | 12.831 | 12.577 | 0.254 | ---- |
| 19 | Mount Diablo, Mount Tamalpais, Monticello. | 12.557 | 12.930 | ---- | 0.373 |

We have the sum of the squares of the closing errors 15.053; hence the average closing error $\sqrt{\frac{15.053}{19}} = \pm 0''.890$ and the probable error of a direction $\frac{0.890}{\sqrt{6}} \times 0.6745 = \pm 0''.245$; but in consequence of one large residual,* 2″.603, in the above table, this average value is injuriously affected, and we prefer to reject it; we then have the probable error of a direction $= \pm 0''.187 = e_t$.

We next square the probable error attached to each of the thirty-four observed directions as given in the preceding abstract of measures, and find the sum of the squares equal to 0.220; hence the average probable error of an observed direction

$$\sqrt{\frac{0.220}{34}} = \pm 0''.081 = e_s$$

Now by comparing the values of $e_s$ and of $e_t$ we meet with the ordinary experience that $e_t$ is larger than $e_s$, in the present case more than twice as large, though the ordinary ratio is rather below $1\frac{1}{2}$.

The value of $e_t$ includes the pure observing error; hence we shall have the pure combination error by the expression $e_c = \sqrt{e_t^2 - e_s^2} = \pm 0''.169$, which is a constant quantity for the figure under consideration, and is to be combined with every probable error of observation $e_s$ in order to obtain the appropriate probable error and consequent weight of each direction as needed for the figure adjustment. We have

$e^2 = e_s^2 + e_c^2$; hence the weight or $\frac{1}{e^2} = \frac{1}{e_s^2 + (0.169)^2} = p$.

*Due to abnormal causes.

The following table contains for each direction (the numbers refer to those in the diagram) the square of the pure observing error and the reciprocal of the weight or $\frac{1}{p}$:

| Direction number. | $e_s^2$ | $\frac{1}{p}=e^2$ | Direction number. | $e_s^2$ | $\frac{1}{p}=e^2$ | Remarks. |
|---|---|---|---|---|---|---|
| 1 | .0072 | .0358 | 18 | .0114 | .0400 | Ratio of minimum to maximum weight 300 : 418, or 1 : 1.4 nearly, but had we used weights depending on the station measures alone the ratio would have been 14 : 132, or 1 : 9.4 nearly, and the value of the method here adopted depends chiefly on the fact that it permits of a proper degree of equalization of the weights. At the same time it is apparent that the value of $e_c$ is somewhat uncertain, but it may vary between rather wide limits without injuriously affecting the solution. For convenience of computing, $\frac{100}{p}$ instead of $\frac{1}{p}$ is introduced in the adjustment now to be explained. |
| 2 | 62 | 348 | 19 | 38 | 324 | |
| 3 | 55 | 341 | 20 | 27 | 313 | |
| 4 | 18 | 304 | 21 | 90 | 376 | |
| 5 | 14 | 300 | 22 | 44 | 330 | |
| 6 | 64 | 350 | 23 | 81 | 367 | |
| 7 | 45 | 331 | 24 | 96 | 382 | |
| 8 | 35 | 321 | 25 | 132 | 418 | |
| 9 | 53 | 339 | 26 | 112 | 398 | |
| 10 | 41 | 327 | 27 | 58 | 344 | |
| 11 | 69 | 355 | 28 | 128 | 414 | |
| 12 | 114 | 400 | 29 | 34 | 320 | |
| 13 | 106 | 392 | 30 | 50 | 336 | |
| 14 | 117 | 403 | 31 | 74 | 360 | |
| 15 | 26 | 312 | 32 | 52 | 338 | |
| 16 | 71 | 357 | 33 | 38 | 324 | |
| 17 | 44 | 330 | 34 | 28 | 314 | |

*Adjustment of a triangulation-net or of conditioned observations.*

We shall here only briefly recapitulate the leading formulæ applicable to the case, inclusive of those for computing the probable error of a function of the adjusted quantities.

Suppose we have as the direct result of observation the $m$ quantities $l_1\ l_2\ l_3\ l_4$ . . . . which are connected by $n$ conditions, and let $x_1\ x_2\ x_3\ x_4$ . . . . . be their most probable values (to be found by applying the method of least squares); also let $v_1\ v_2\ v_3\ v_4$ . . . . be the corrections to the observations, so that in general $x_i = l_i + v_i$, and remembering that necessarily $m > n$ in order that any adjustment may exist at all, then these conditions may be expressed by $n$ equations of linear form, thus:

$$
\begin{aligned}
a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + \ldots\ldots &= 0\\
b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + \ldots\ldots &= 0\\
c_1x_1 + c_2x_2 + c_3x_3 + c_4x_4 + \ldots\ldots &= 0\\
\ldots\ldots\ldots\ldots &
\end{aligned}
$$

The observed values $l_i$ will not satisfy these equations, but will exhibit discrepancies $w_i$, whence we write the $n$ conditional equations

$$
\begin{aligned}
a_1v_1 + a_2v_2 + a_3v_3 + a_4v_4 + \ldots\ldots + w_1 &= 0\\
b_1v_1 + b_2v_2 + b_3v_3 + b_4v_4 + \ldots\ldots + w_2 &= 0\\
c_1v_1 + c_2v_2 + c_3v_3 + c_4v_4 + \ldots\ldots + w_3 &= 0\\
\ldots\ldots\ldots\ldots &
\end{aligned}
$$

where the sign of $w_i$ is to be taken in the sense of observed value minus true value. Let $p_1\ p_2\ p_3\ p_4$ . . . be the weights of the quantities $l_1\ l_2\ l_3\ l_4$ . . . . . then the quantity $[p\,.\,vv]$ must be made a minimum. This leads to the equations of correlates which contain the (as yet) unknown multipliers $C_1\ C_2\ C_3$ . . . . . These correlate equations are:

$$
\begin{aligned}
p_1v_1 &= a_1C_1 + b_1C_2 + c_1C_3 + \ldots\\
p_2v_2 &= a_2C_1 + b_2C_2 + c_2C_3 + \ldots\\
p_3v_3 &= a_3C_1 + b_3C_2 + c_3C_3 + \ldots\\
&\text{etc.}
\end{aligned}
$$

Substituting the values of $v$ in the conditional equations there result the normal equations:

$$\left[\frac{aa}{p}\right] C_1 + \left[\frac{ab}{p}\right] C_2 + \left[\frac{ac}{p}\right] C_3 + \quad . \quad . \quad . \quad . \quad . \quad . \quad + w_1 = 0$$

$$\left[\frac{ab}{p}\right] C_1 + \left[\frac{bb}{p}\right] C_2 + \left[\frac{bc}{p}\right] C_3 + \quad . \quad . \quad . \quad . \quad . \quad . \quad + w_2 = 0$$

$$\left[\frac{ac}{p}\right] C_1 + \left[\frac{bc}{p}\right] C_2 + \left[\frac{cc}{p}\right] C_3 + \quad . \quad . \quad . \quad . \quad . \quad . \quad + w_3 = 0$$

. . . . . . . . . . . . .

for these we prefer to write after putting $u = \frac{1}{p}$

$$\left\{\begin{array}{l} [u.\ aa]\, C_1 + [u.\ ab]\, C_2 + [u.\ ac]\, C_3 + \quad . \quad . \quad . \quad . \quad + w_1 = 0 \\ \qquad\qquad + [u.\ bb]\, C_2 \mp [u.\ bc]\, C_3 + \quad . \quad . \quad . \quad . \quad + w_2 = 0 \\ \qquad\qquad\qquad\qquad + [u.\ cc]\, C_3 + \quad . \quad . \quad . \quad . \quad + w_3 = 0 \\ \qquad\qquad\qquad\qquad\qquad\qquad + \quad . \quad . \quad . \quad . \end{array}\right.$$

Solvi g these equations the values of $C_i$ become known, and consequently also the values of $v_i$ and $x$.

We have further the mean error of an observation of the weight *one*, $m_1 = \sqrt{\frac{[pvv]}{n}}$ and the probable error of the same $r_1 = 0.6745\sqrt{\frac{[pvv]}{n}}$. The sum $[pvv]$ is found by means of the individual corrections to the observed values and is checked by the relation : $[pvv] = -[wC]$.

To find the weight and probable error of an adjusted value of an observation, also the weight P of any function F of the adjusted observations, we suppose

$$F = f_1 x_1 + f_2 x_2 + f_3 x_3 + f_4 x_4 + \quad . \quad . \quad . \quad . \quad .$$

which function cannot contain all the $x$'s but only $m - n$ of them. The coefficients $f_i$ are found by partial differentiation,* viz:

$$\frac{\delta F}{dx_1} = f_1 \qquad \frac{\delta F}{dx_2} = f_2 \qquad \frac{\delta F}{dx_3} = f_3 \text{ etc.}$$

We next form the sums:

$$\left[\frac{af}{p}\right] \quad \left[\frac{bf}{p}\right] \quad \left[\frac{cf}{p}\right] \text{ etc.}$$

and combine these with the former normal equations, at the same time introducing a new set of indeterminate coefficients $R_1$, $R_2$, $R_3$, etc., in the place of the former $C_1$, $C_2$, $C_3$, etc. Then the requirement of the conditioned minimum leads to the following so called (by Gerling) transfer-equations:

$$\left\{\begin{array}{l} [u.\ aa]\, R_1 + [u.\ ab]\, R_2 + [u.\ ac]\, R_3 + \quad . \quad . \quad . \quad . \quad + [u.\ af] = 0 \\ \qquad\qquad + [u.\ bb]\, R_2 + [u.\ bc]\, R_3 + \quad . \quad . \quad . \quad . \quad + [u.\ bf] = 0 \\ \qquad\qquad\qquad\qquad + [u.\ cc]\, R_3 + \quad . \quad . \quad . \quad . \quad + [u.\ cf] = 0 \\ \qquad\qquad\qquad\qquad\qquad\qquad + \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \end{array}\right.$$

Their solution furnishes the transfer-coefficients $R_i$, and consequently also the values $F_i$ by means of the relations:

$$\begin{array}{l} F_1 = f_1 + a_1 R_1 + b_1 R_2 + c_1 R_3 + \quad . \quad . \quad . \quad . \quad . \quad . \\ F_2 = f_2 + a_2 R_1 + b_2 R_2 + c_2 R_3 + \quad . \quad . \quad . \quad . \quad . \quad . \\ F_3 = f_3 + a_3 R_1 + b_3 R_2 + c_3 R_3 + \quad . \quad . \quad . \quad . \quad . \quad . \\ F_4 = f_4 + a_4 R_1 + b_4 R_2 + c_4 R_3 + \quad . \quad . \quad . \quad . \quad . \quad . \\ \text{etc.} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \end{array}$$

* In the absence of a special letter to indicate this, $\delta$ is here substituted.

and finally we have the reciprocal of the weight P of the function F by

$$\frac{1}{P} = [u \,.\, FF]$$

also the mean error of F, or

$$m_F = \frac{m_1}{\sqrt{P}} = m_1 \sqrt{[u \,.\, FF]}$$

and the probable error of F, or

$$r_F = 0.6745 \; m_F$$

The mean error of any one value of $x$, that is, of the result of any given observation after adjustment, is determined in the same way by regarding $x_i$ as a function $F_i$ of the observations.

*Application to the adjustment of the Yolo base-net.*

The number of conditions in the Yolo base-net is 17; of these 11 are related to angles and 6 to ratio of sides. Corrections to directions are indicated by placing the numbers within parentheses. In the log's of the sines nine places of decimals are used, and the numbers for logarithm difference of 1″ are cut off at the sixth place of decimals.

*Conditional equations.*

1 $(4) - (3) + (16) - (15) + (8) - (5) - 0.814 = 0$

2 $(3) - (2) + (10) - (14) + (17) - (16) + 0.043 = 0$

3 $(4) - (2) + (10) - (9) + (7) - (5) - 1.041 = 0$

4 $(6) - (5) + (4) - (1) + (26) - (25) - 0.726 = 0$

5 $(7) - (6) + (11) - (9) + (25) - (24) + 0.178 = 0$

6 $(3) - (1) + (18) - (16) + (26) - (23) - 0.313 = 0$

7 $(19) - (17) + (14) - (12) + (33) - (32) + 0.071 = 0$

8 $(20) - (19) + (32) - (31) + (30) - (27) - 0.349 = 0$

9 $(20) - (17) + (14) - (13) + (28) - (27) + 0.779 = 0$

10 $(24) - (22) + (29) - (28) + (13) - (11) - 2.603 = 0$

11 $(22) - (21) + (34) - (31) + (30) - (29) + 0.254 = 0$

12 $+ 1.9606\,(2) - 1.3048\,(3) - 0.6558\,(4) + 1.9400\,(5) - 3.3408\,(7) + 1.4008\,(8) + 0.4743\,(15) - 1.7604\,(16) + 1.2861\,(17) + 1.046 = 0$

13 $+ 1.9044\,(1) - 1.2486\,(2) - 0.6558\,(4) + 1.9400\,(5) - 4.0847\,(6) + 2.1447\,(7) + 1.4167\,(24) - 6.3593\,(25) + 4.9426\,(26) - 2.809 = 0$

14 $+ 1.9044\,(1) - 3.2092\,(2) + 1.3048\,(3) + 1.7604\,(16) - 258.7574\,(17) + 256.9970\,(18) + 439.1792\,(23) - 444.1218\,(24) + 4.9426\,(26) + 198.013 = 0$

15 $+ 1.9044\,(1) - 3.2092\,(2) + 1.3048\,(3) + 1.7604\,(16) - 4.3015\,(17) + 2.5411\,(19) + 0.7609\,(21) - 5.7035\,(24) + 4.9426\,(26) + 6.3336\,(32) - 7.9444\,(33) + 1.6108\,(34) - 5.817 = 0$

16 $+ 0.7609\,(21) - 5.6818\,(22) + 4.9209\,(24) + 4.2562\,(28) - 5.8046\,(29) + 1.5484\,(30) + 2.1886\,(31) - 3.7994\,(33) + 1.6108\,(34) - 3.964 = 0$

17 $+ 3.1922\,(17) - 2.5411\,(19) - 0.6511\,(20) + 3.2065\,(27) - 4.7549\,(28) + 1.5484\,(30) + 2.1886\,(31) - 6.3336\,(32) + 4.1450\,(33) - 1.205 = 0$

*Correlate equations.*

| Corrections. | $u=\frac{100}{P}$ | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ | $C_8$ | $C_9$ | $C_{10}$ | $C_{11}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $v_1$ | 3.58 | | | | −1 | | −1 | | | | | |
| $v_2$ | 3.48 | | −1 | −1 | | | | | | | | |
| $v_3$ | 3.41 | −1 | +1 | | | | +1 | | | | | |
| $v_4$ | 3.04 | +1 | | +1 | +1 | | | | | | | |
| $v_5$ | 3.00 | −1 | ---- | −1 | −1 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| $v_6$ | 3.50 | | | | +1 | −1 | | | | | | |
| $v_7$ | 3.31 | | | +1 | | +1 | | | | | | |
| $v_8$ | 3.21 | +1 | | | | | | | | | | |
| $v_9$ | 3.39 | | | −1 | | −1 | | | | | | |
| $v_{10}$ | 3.27 | ---- | +1 | +1 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| $v_{11}$ | 3.55 | | | | | +1 | | | | | −1 | |
| $v_{12}$ | 4.00 | | | | | | | −1 | | | | |
| $v_{13}$ | 3.92 | | | | | | | | | −1 | +1 | |
| $v_{14}$ | 4.03 | | −1 | | | | | 1 | | +1 | | |
| $v_{15}$ | 3.12 | −1 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| $v$ | 3.57 | 1 | −1 | | | | −1 | | | | | |
| $v_{17}$ | 3.30 | | +1 | | | | | −1 | | −1 | | |
| $v_{18}$ | 4.00 | | | | | | +1 | | | | | |
| $v_{19}$ | 3.24 | | | | | | | +1 | −1 | | | |
| $v$ | 3.13 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 1 | +1 | ---- | ---- |
| $v$ | 3.76 | | | | | | | | | | | −1 |
| $v_{22}$ | 3.30 | | | | | | | | | | −1 | +1 |
| $v_{23}$ | 3.67 | | | | | | −1 | | | | | |
| $v_{24}$ | 3.82 | | | | | −1 | | | | | +1 | |
| $v$ | 4.18 | ---- | ---- | ---- | −1 | +1 | ---- | ---- | ---- | ---- | ---- | ---- |
| $v_{26}$ | 3.98 | | | | +1 | | 1 | | | | | |
| $v_{27}$ | 3.44 | | | | | | | | −1 | −1 | | |
| $v_{28}$ | 4.14 | | | | | | | | | +1 | −1 | |
| $v_{29}$ | 3.20 | | | | | | | | | | +1 | −1 |
| $v_{30}$ | 3.36 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | +1 | ---- | ---- | +1 |
| $v_{31}$ | 3.60 | | | | | | | | −1 | | | −1 |
| $v_{32}$ | 3.38 | | | | | | | −1 | +1 | | | |
| $v_{33}$ | 3.24 | | | | | | | +1 | | | | |
| $v_{34}$ | 3.14 | | | | | | | | | | | +1 |
| | | −.814 | +.043 | −1.041 | −.726 | +.178 | −.313 | +.071 | −.349 | +.779 | −2.603 | +.254 |

*Correlate equations.*

| $C_{12}$ | $C_{13}$ | $C_{14}$ | $C_{15}$ | $C_{16}$ | $C_{17}$ |
|---|---|---|---|---|---|
| | +1.9044 | + 1.9044 | +1.9044 | | |
| +1.9606 | −1.2486 | − 3.2092 | −3.2092 | | |
| −1.3048 | | 1.3048 | +1.3048 | | |
| −0.6558 | −0.6558 | | | | |
| +1.9400 | +1.9400 | ------ | ------ | ------ | ------ |
| | −4.0847 | | | | |
| −3.3408 | +2.1447 | | | | |
| +1.4008 | | | | | |
| ------ | ------ | ------ | ------ | ------ | ------ |
| +0.4743 | ------ | ------ | ------ | ------ | ------ |
| 1.7604 | | + 1.7604 | +1.7604 | | |
| +1.2861 | | −258.7574 | −4.3015 | | +3.1922 |
| | | +256.9970 | | | |
| | | | +2.5411 | | −2.5411 |
| ------ | ------ | ------ | ------ | ------ | −0.6511 |
| | | | +0.7609 | +0.7609 | |
| | | | | −5.6818 | |
| | | +439.1792 | | | |
| | +1.4167 | −444.1218 | −5.7035 | +4.9209 | |
| ------ | −6.3593 | ------ | ------ | ------ | ------ |
| | +4.9426 | + 4 9426 | +4.9426 | | |
| | | | | | +3.2065 |
| | | | | +4.2562 | −4.7549 |
| | | | | −5.8046 | |
| ---- | ------ | ------ | ------ | +1.5484 | +1.5484 |
| | | | | +2.1886 | +2.1886 |
| | | | +6.3336 | | −6.3336 |
| | | | −7.9444 | −3.7994 | +4.1450 |
| | | | +1.6108 | +1.6108 | |
| +1.046 | −2.809 | +198.013 | −5.817 | −3.964 | −1.205 |

*Normal equations*

| $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | C | C | $C_8$ | $C_9$ | $C_{10}$ | C |
|---|---|---|---|---|---|---|---|---|---|---|
| +19.35 | − 6.98 | + 6.04 | + 6.04 | | − 6.98 | | | | | |
| | +21.06 | + 6.75 | | | + 6.98 | − 7.33 | | − 7.33 | | |
| | | +19.49 | + 6.04 | + 6.70 | ---- | ---- | ---- | ---- | ---- | ---- |
| | | | +21.28 | − 7.68 | + 7.56 | | | | | |
| | | | | +21.75 | | | | | − 7.37 | |
| | | | | | +22.21 | ---- | ---- | ---- | ---- | ---- |
| | | | | | | +21.19 | − 6.62 | + 7.33 | | |
| | | | | | | | +20.15 | + 6.57 | | + 6.96 |
| | | | | | | | | +21.96 | − 8.06 | ---- |
| | | | | | | | | | +21.93 | − 6.50 |
| | | | | | | | | | | +20.36 |

These equations were solved by Mr. M. H. Doolittle by the method

**Resulting values of $C_i$.**

$C_1 = + .033900$
$C_2 = + .023593$
$C_3 = + .010217$
$C_4 = + .043760$
$C_5 = + .066122$
$C_6 = - .011325$
$C_7 = + .019388$
$C_8 = + .009930$
$C_9 = + .039218$
$C_{10} = + .163816$
$C_{11} = + .036790$
$C_{12} = + .0175652$
$C_{13} = + .0002761$
$C_{14} = - .000088967$
$C_{15} = + .0198674$
$C_{16} = + .0120203$
$C_{17} = + .0161153$

**Residuals are all between − .0001 and + .0001 .**

*Yolo base-net.*

| $C_{12}$ | $C_{13}$ | $C_{14}$ | $C_{15}$ | $C_{16}$ | $C_{17}$ | | |
|---|---|---|---|---|---|---|---|
| − 6.632₁ | − 7.8136 | + 1.8353 | + 1.8353 | | | − 0.814 | = 0 |
| − 0.7435 | + 4.3451 | − 844.5667 | − 4.8622 | | + 10.5343 | + 0.043 | = 0 |
| −25.6946 | + 3.6305 | + 11.1680 | + 11.1680 | ...... | ...... | − 1.041 | = 0 |
| − 7.8136 | + 17.3256 | + 12.8538 | + 12.8538 | | | − 0.726 | = 0 |
| −11.0580 | − 10.5983 | + 1696.5453 | + 21.7874 | − 18.7978 | | + 0.178 | = 0 |
| + 1.8353 | + 12.8538 | − 572.7811 | + 11.0185 | ...... | ...... | − 0.313 | = 0 |
| − 4.2441 | | + 853.8994 | − 24.7193 | − 12.3101 | + 16.0699 | + 0.071 | = 0 |
| | | | + 13.1744 | − 2.6763 | − 28.9190 | 0.349 | = 0 |
| − 4.2441 | ...... | + 853.8994 | + 14.1950 | + 17.6207 | − 43.2878 | + 0.779 | = 0 |
| | + 5.4118 | − 1696.5453 | − 21.7874 | + 1.3524 | + 19.6853 | − 2.603 | = 0 |
| | | | + 2.1969 | − 0.6546 | − 2.6763 | + 0.254 | = 0 |
| +92.2459 | − 19.6370 | − 1136.9650 | − 57.0211 | ...... | + 13.5481 | + 1.046 | = 0 |
| | +378.5667 | − 2279.3390 | + 93.2905 | + 26.6309 | | − 2.809 | = 0 |
| | | +1946641.9064 | +13512.2160 | − 8348.5296 | −2725.8177 | +198.013 | = 0 |
| | | | + 719.5657 | + 0.9067 | − 308.5131 | − 5.817 | = 0 |
| | | | | + 464.2463 | − 109.5101 | − 3.964 | = 0 |
| | | | | | + 401.3992 | − 1.205 | = 0 |

devised by him, Mr. A. Ziwet assisting in the solution.

Resulting values of $v$.

| ″ | ″ | ″ |
|---|---|---|
| $v_1 = +.0206$ | $v_{12} = -.0776$ | $v_{23} = -.1018$ |
| $v_2 = -.2199$ | $v_{13} = +.4884$ | $v_{24} = +.3187$ |
| $v_3 = -.0639$ | $v_{14} = +.1411$ | $v_{25} = +.0861$ |
| $v_4 = +.2316$ | $v_{15} = -.0798$ | $v_{26} = +.5236$ |
| $v_5 = -.1598$ | $v_{16} = +.0911$ | $v_{27} = +.0083$ |
| $v_6 = -.0822$ | $v_{17} = -.0773$ | $v_{28} = -.6213$ |
| $v_7 = +.0604$ | $v_{18} = -.1368$ | $v_{29} = +.1832$ |
| $v_8 = +.1878$ | $v_{19} = +.0615$ | $v_{30} = +.3034$ |
| $v_9 = -.2588$ | $v_{20} = +.1210$ | $v_{31} = +.0535$ |
| $v_{10} = +.1106$ | $v_{21} = -.0471$ | $v_{32} = +.0484$ |
| $v_{11} = -.3468$ | $v_{22} = -.6446$ | $v_{33} = -.3801$ |
| | | $v_{34} = +.2768$ |

We have for check $[p \cdot vv] = 0.6245$ and $-[wC] = 0.6249$, which shows a satisfactory accord.

The mean error of an observed direction of unit weight equals

$$\sqrt{\frac{.6247}{17}} = \pm\ 0''.192$$

and since the average reciprocal of weight equals 3.51, the average weight of a direction is 0.285 ; hence the *mean error* (after figure-adjustment) of an observed *direction* of average weight*

$$m = \frac{m_1}{\sqrt{P_0}} = \frac{0.192}{\sqrt{.285}} = \pm\ 0''.359$$

also the corresponding mean error of an observed *angle* of average weight $= 0.359\sqrt{2} = \pm\ 0''.508$

We have further the *probable error* (after adjustment) of an observed *direction* of average weight,† $r = 0.6745\, m = \pm\ 0''.242$, also the corresponding *probable error* of an observed *angle* of average weight $= .242\sqrt{2} = \pm\ 0''.343$

The mean error $m$ of an adjusted angle is a quantity which has been advantageously used to serve as a practical basis of comparison of the accuracy of triangulations, and may be taken as a convenient average measure for that purpose. In magnitude it does not exceed 1″ for the best work executed, and that limit may be taken to separate the best from moderately good work. In the following table those values of $m$, not our own, were taken from Jordan's work (Vermessungskunde), Vol. II, § 50.

| | |
|---|---|
| Davidson, Coast and Geodetic Survey, Yolo base-net, California, 1876–'84 | $m = \pm\ 0''.51$ |
| Gauss, Survey in Hanover | 0.59 |
| v. Morozowicz, Survey of Prussia since 1867 | 0.62 |
| Andrae, Survey of Denmark | 0.71 |
| Bessel and Bayer, Survey in East Prussia, 1838 | 0.72 |
| Boutelle, Coast and Geodetic Survey, New York State, 1880–'83 | 0.99 |

As a work of secondary accuracy we may mention here the so-called "horseshoe" triangulation of Eastern Pennsylvania by the Coast and Geodetic Survey, 1875 to 1882, for which $m = \pm\ 1''.75$ For the British Ordnance Survey, $m = \pm\ 2''.21$

*Determination of the probable error of the adjusted length of the primary side, Mount Helena to Mount Diablo.*

From the relation, side Mount Helena to Mount Diablo =

$$\text{Yolo base} \times \frac{\sin(2-1)\sin(7-5)\sin(13-11)}{\sin(10-9)\sin(26-24)\sin(29-28)}$$

we have:

$$F = \log\sin(2-1) + \log\sin(7-5) + \log\sin(13-11) - \log\sin(10-9) - \log\sin(26-24)$$

$$-\log\sin(29-28) \qquad f_i = \frac{\delta F}{dx_i} = \frac{M}{\rho}\cot x_i = M\sin 1''\cot x_i$$

which may be taken from logarithmic tables (in units of the 6th place of decimals). The values of $f_i$ are as follows:

| | |
|---|---|
| $f_1 = -1.9043$ | $f_{11} = +2.4854$ |
| $f_2 = +1.9043$ | $f_{13} = -2.4854$ |
| $f_5 = -1.9400$ | $f_{24} = +4.9427$ |
| $f_7 = +1.9400$ | $f_{26} = -4.9427$ |
| $f_9 = +4.4428$ | $f_{28} = +5.8045$ |
| $f_{10} = -4.4428$ | $f_{29} = -5.8045$ |

*This may be roughly compared with the expression $\sqrt{\frac{[vv]}{n}} = \sqrt{\frac{2.249}{17}} = \pm\ 0''.364$, which is practically the same as the above value of $m$.

†The *probable* error of an average direction may be roughly compared with the value derived from the closing errors of the 19 triangles, which we have found to be $\pm\ 0''.245$, and which compares well with the above value, $r = \pm\ 0''.242$

It will not be required to write out in full the transfer equations; it suffices to substitute in the normal equations $R_i$ for $C_i$ and to replace the absolute numbers in the last vertical column by the following numbers:

| | |
|---|---|
| $[u.af] = + \ 5.820$ | $[u.if] = + \ 33.773$ |
| $[u.bf] = - 21.155$ | $[u.jf] = - \ 42.290$ |
| etc. $= - 23.975$ | etc. $= + \ 18.574$ |
| $= - \ 7.034$ | $= - \ 19.750$ |
| $= - 18.698$ | $= - \ 89.258$ |
| $= - 12.855$ | $= - 8516.995$ |
| $= \ 0$ | $= - \ 239.169$ |
| $= \ 0$ | $= + \ 303.008$ |
| | $= - \ 114.263$ |

The solution* of the transfer equations gave the values of $R_i$

| | |
|---|---|
| $R_1 = - \ .611$ | $R_9 = + \ .666$ |
| $R_2 = + \ .352$ | $R_{10} = + 2.5$ |
| $R_3 = + 2.43$ | $R_{11} = - \ .215$ |
| $R_4 = + \ .096$ | $R_{12} = + 1.34$ |
| $R_5 = + \ .57$ | $R_{13} = + \ .122$ |
| $R_6 = - \ .258$ | $R_{14} = + \ .000\,507$ |
| $R_7 = + \ .273$ | $R_{15} = + \ .675$ |
| $R_8 = + \ .246$ | $R_{16} = - \ .52$ |
| | $R_{17} = + \ .565$ |

The above values left reasonably small residuals. The values of $F_i = f_i + a_i R_1 + b\, R_2 + c_i R_3 + \ . \ . \ . \ . \ .$ were next found; they are:

| | |
|---|---|
| $F_1 = - 0.224$ | $F_{18} = - 0.128$ |
| $F_2 = - 0.570$ | $F_{19} = + 0.306$ |
| $F_3 = - 0.162$ | $F_{20} = + 0.544$ |
| $F_4 = + 0.956$ | $F_{21} = + 0.333$ |
| $F_5 = - 1.019$ | $F_{22} = + 0.240$ |
| $F_6 = - 0.972$ | $F_{23} = + 0.482$ |
| $F_7 = + 0.725$ | $F_{24} = + 0.410$ |
| $F_8 = + 1.266$ | $F_{25} = - 0.302$ |
| $F_9 = + 1.443$ | $F_{26} = - 1.163$ |
| $F_{10} = - 1.661$ | $F_{27} = + 0.899$ |
| $F_{11} = + 0.555$ | $F_{28} = - 0.930$ |
| $F_{12} = - 0.273$ | $F_{29} = - 0.070$ |
| $F_{13} = - 0.651$ | $F_{30} = + 0.101$ |
| $F_{14} = + 0.587$ | $F_{31} = + 0.068$ |
| $F_{15} = + 1.246$ | $F_{32} = + 0.670$ |
| $F_{16} = - 1.874$ | $F_{33} = - 0.772$ |
| $F_{17} = - 0.095$ | $F_{34} = + 0.035$ |

We next form the values $u\, F_i F_i$ and find $[u.FF] = 74.469$ which is the reciprocal of the weight, or $\frac{1}{P}$

The mean error of the function or $m_F = \frac{m_1}{\sqrt{P}} = m_1 \sqrt{[u.FF]} = 0.192 \sqrt{74.469} = \pm 1.654$ expressed in units of the sixth place of decimals of the logarithm of the side. The *probable* error is consequently

$$r_F = 0.6745 \, m_F = \pm 1.116$$

*The solution was effected by Mr. Doolittle; part of the former solution of the normal equations came again into use.

From the triangle-side computation we have:

| | |
|---|---|
| Log distance Mount Helena to Mount Diablo | 5.032 332 465<br>± 1 116 |
| Also distance Mount Helena to Mount Diablo | $107728^m.959$<br>± 0.277 |

To the above uncertainty is yet to be added the probable error arising from that of the measure* of the base line itself; the latter value was $\pm 0^m.00957$, hence the corresponding probable error of primary side Mount Helena to Mount Diablo:

$$0.00957 \frac{\text{Primary side}}{\text{base}} = 0.00957 \frac{107729.0}{17486.5} = \pm 0^m.0589$$

hence total probable error

$$= \sqrt{(.059)^2 + (.277)^2} = \pm 0^m.283$$

and the same when expressed in units of the sixth place of logarithms = ± 1.141 It also corresponds to $\frac{1}{380\ 700}$ part of the length, which for our line is 66.94 statute miles, or 107.73 kilometres, and equals a probable error of ± 0.17 inch per statute mile, or $\pm\ 2^{mm}.63$ per kilometre.

*Triangle-side computation.*

This part of the reduction requires no further explanation. The results are as follows:

| | Stations. | Observed angles. | Corrections. | Spherical angles. | Spherical excess. | Plane angles and distances. | Logarithms. |
|---|---|---|---|---|---|---|---|
| | | ° ′ ″ | ″ | ″ | ″ | | |
| | Yolo, Northwest Base to Southeast Base. | | | | | ±0. 010<br>17486. 512 | ±24<br>4. 2427 0319 |
| | Vaca. | 25 21 21. 287 | +0. 369 | 21. 656 | 0. 424 | 21. 232 | 0. 3683 1309 |
| 1. | Northwest Base. | 47 20 34. 196 | +0. 220 | 34. 416 | 0. 424 | 33. 992 | 9. 8665 3585 |
| | Southeast Base. | 107 18 04. 749 | +0. 452 | 05. 201 | 0. 425 | 04. 776 | 9. 9798 9145 |
| | | | | | 1. 273 | | |
| | Vaca to Southeast Base. | | | | | 30029. 78 | 4. 4775 5213 |
| | Vaca to Northwest Base. | | | | | 38985. 91 | 4. 5909 0773 |
| | Yolo, Northwest Base to Southeast Base. | | | | | | 4. 2427 0319 |
| | Monticello. | 27 12 15. 561 | +0. 171 | 15. 732 | 0. 416 | 15. 316 | 0. 3399 2801 |
| 2. | Northwest Base. | 103 42 21. 392 | +0. 348 | 21. 740 | 0. 415 | 21. 325 | 9. 9874 5381 |
| | Southeast Base. | 49 05 23. 480 | +0. 295 | 23. 775 | 0. 416 | 23. 359 | 9. 8783 7077 |
| | | | | | 1. 247 | | |
| | Monticello to Southeast Base. | | | | | 37160. 80 | 4. 5700 8501 |
| | Monticello to Northwest Base. | | | | | 28906. 93 | 4. 4610 0197 |
| | Monticello to Southeast Base. | | | | | | 4. 5700 8501 |
| | Vaca. | 71 41 15. 803 | −0. 031 | 15. 772 | 0. 802 | 14. 970 | 0. 0225 7048 |
| 3. | Monticello. | 50 06 05. 379 | −0. 168 | 05. 211 | 0. 803 | 04. 408 | 9. 8848 9663 |
| | Southeast Base. | 58 12 41. 269 | +0. 156 | 41. 425 | 0. 803 | 40. 622 | 9. 9294 1712 |
| | | | | | 2. 408 | | |
| | Vaca to Southeast Base. | | | | | 30029. 78 | 4. 4775 5212 |
| | Vaca to Monticello. | | | | | 33271. 52 | 4. 5220 7261 |

*Coast and Geodetic Survey Report for 1883, Appendix No. 11.

*Triangle-side computation*—Continued.

| | Stations. | Observed angles. | Corrections. | Spherical angles. | Spherical excess. | Plane angles and distances. | Logarithms. |
|---|---|---|---|---|---|---|---|
| | | ° ′ ″ | ″ | ″ | ″ | | |
| | Northwest Base to Vaca. | | | | | | 4.5909 0773 |
| | Monticello. | 77 18 20.940 | +0.003 | 20.943 | 0.794 | 20.149 | 0.0107 4779 |
| 4. | Northwest Base. | 56 21 47.196 | +0.127 | 47.323 | 0.794 | 46.529 | 9.9204 1709 |
| | Vaca. | 46 19 54.516 | −0.400 | 54.116 | 0.794 | 53.322 | 9.8593 4645 |
| | | | | | 2.382 | | |
| | Monticello to Vaca. | | | | | 33271.52 | 4.5220 7261 |
| | Monticello to Northwest Base. | | | | | 28906.93 | 4.4610 0197 |
| | Northwest Base to Southeast Base. | | | | | | 4.2427 0319 |
| | Mount Diablo. | 4 45 11.792 | +0.437 | 12.229 | 0.450 | 11.779 | 1.0816 2825 |
| 5. | Northwest Base. | 20 04 24.632 | +0.078 | 24.710 | 0.450 | 24.260 | 9.5355 7735 |
| | Southeast Base. | 155 10 24.200 | +0.211 | 24.411 | 0.450 | 23.961 | 9.6231 1971 |
| | | | | | 1.350 | | |
| | Mount Diablo to Southeast Base. | | | | | 72428.38 | 4.8599 0879 |
| | Mount Diablo to Northwest Base. | | | | | 88603.56 | 4.9474 5115 |
| | Vaca to Northwest Base. | | | | | | 4.5909 0773 |
| | Mount Diablo. | 18 19 09.648 | −0.233 | 09.415 | 1.339 | 08.076 | 0.5026 4762 |
| 6. | Vaca. | 134 24 44.984 | −0.088 | 44.896 | 1.340 | 43.556 | 9.8538 9580 |
| | Northwest Base. | 27 16 09.564 | +0.143 | 09.707 | 1.339 | 08.368 | 8.6610 2528 |
| | | | | | 4.018 | | |
| | Mount Diablo to Northwest Base. | | | | | 88603.56 | 4.9474 5115 |
| | Mount Diablo to Vaca. | | | | | 56830.39 | 4.7545 8063 |
| | Vaca to Southeast Base. | | | | | | 4.4775 5212 |
| | Mount Diablo. | 23 04 21.440 | +0.205 | 21.645 | 1.365 | 20.280 | 0.4068 3319 |
| 7. | Vaca. | 109 03 23.697 | −0.457 | 23.240 | 1.365 | 21.875 | 9.9755 2348 |
| | Southeast Base. | 47 52 19.451 | −0.241 | 19.210 | 1.365 | 17.845 | 9.8701 9532 |
| | | | | | 4.095 | | |
| | Mount Diablo to Southeast Base. | | | | | 72428.38 | 4.8599 0879 |
| | Mount Diablo to Vaca. | | | | | 56830.39 | 4.7545 8063 |
| | Monticello to Northwest Base. | | | | | | 4.4610 0197 |
| | Mount Diablo. | 18 35 38.518 | +0.188 | 38.706 | 2.154 | 36.552 | 0.4964 1144 |
| 8. | Monticello. | 77 46 30.784 | −0.057 | 30.727 | 2.154 | 28.573 | 9.9900 3773 |
| | Northwest Base. | 83 37 56.760 | +0.270 | 57.030 | 2.155 | 54.875 | 9.9973 1204 |
| | | | | | 6.463 | | |
| | Mount Diablo to Northwest Base. | | | | | 88603.56 | 4.9474 5114 |
| | Mount Diablo to Monticello. | | | | | 90100.14 | 4.9547 2545 |
| | Monticello to Southeast Base. | | | | | | 4.5700 8501 |
| | Mount Diablo. | 23 20 50.310 | +0.625 | 50.935 | 2.189 | 48.746 | 0.4019 7948 |
| 9. | Monticello. | 50 34 15.223 | −0.228 | 14.995 | 2.189 | 12.806 | 9.8878 4429 |
| | Southeast Base. | 106 04 60.720 | −0.084 | 60.636 | 2.188 | 58.448 | 9.9826 6096 |
| | | | | | 6.566 | | |
| | Mount Diablo to Southeast Base. | | | | | 72428.38 | 4.8599 0878 |
| | Mount Diablo to Monticello. | | | | | 90100.14 | 4.9547 2545 |

*Triangle-side computation*—Continued.

| | Stations. | Observed angles. | Corrections. | Spherical angles. | Spherical excess. | Plane angles and distances. | Logarithms. |
|---|---|---|---|---|---|---|---|
| | | ° ′ ″ | ″ | ″ | ″ | | |
| | Monticello to Vaca. | | | | | | 4. 5220 7261 |
| | Mount Diablo. | 0 16 28. 870 | +0. 4200 | 29. 2900 | 0. 021 | 29. 2690 | 2. 3191 1240 |
| 10* | Monticello. | 0 28 09. 844 | −0. 0607 | 09. 7833 | 0. 021 | 09. 7623 | 7. 9133 9562 |
| | Vaca. | 179 15 20. 500 | +0. 4887 | 20. 9887 | 0. 020 | 20. 9687 | 8. 1135 4044 |
| | | | | | 0. 062 | | |
| | Mount Diablo to Vaca. | | | | | 56830. 39 | 4. 7545 8063 |
| | Mount Diablo to Monticello. | | | | | 90100. 14 | 4. 9547 2545 |
| | Monticello to Vaca. | | | | | | 4. 5220 7261 |
| | Mount Helena. | 33 17 28. 028 | −0. 630 | 27. 398 | 1. 038 | 26. 360 | 0. 2605 1745 |
| 11. | Monticello. | 107 11 02. 769 | +0. 198 | 02. 967 | 1. 037 | 01. 930 | 9. 9801 6777 |
| | Vaca. | 39 31 33. 095 | −0. 347 | 32. 748 | 1. 038 | 31. 710 | 9. 8037 4467 |
| | | | | | 3. 113 | - | |
| | Mount Helena to Vaca. | | | | | 57910. 57 | 4. 7627 5783 |
| | Mount Helena to Monticello. | | | | | 38577. 56 | 4. 5863 3473 |
| | Mount Helena to Vaca. | | | | | | 4. 7627 5783 |
| | Mount Diablo. | 20 19 59. 563 | +0. 963 | 60. 526 | 1. 800 | 58. 726 | 0. 4590 7588 |
| 12. | Mount Helena. | 19 56 15. 830 | +0. 805 | 16. 635 | 1. 800 | 14. 835 | 9. 5327 4692 |
| | Vaca. | 139 43 47. 405 | +0. 835 | 48. 240 | 1. 801 | 46. 439 | 9. 8104 9875 |
| | | | | | 5. 401 | | |
| | Mount Diablo to Vaca. | | | | | 56830. 39 | 4. 7545 8063 |
| | Mount Diablo to Mount Helena. | | | | | 107728. 96 | 5. 0323 3246 |
| | Mount Helena to Monticello. | | | | | | 4. 5863 3473 |
| | Mount Diablo. | 20 03 30. 693 | +0. 543 | 31. 236 | 2. 817 | 28. 419 | 0. 4647 4453 |
| 13. | Mount Helena. | 53 13 43. 858 | +0. 175 | 44. 033 | 2. 817 | 41. 216 | 9. 9036 4619 |
| | Monticello. | 106 42 52. 925 | +0. 258 | 53. 183 | 2. 818 | 50. 365 | 9. 9812 5320 |
| | | | | | 8. 452 | | |
| | Mount Diablo to Monticello. | | | | | 90100. 14 | 4. 9547 2545 |
| | Mount Diablo to Mount Helena. | | | | | 107728. 96 | 5. 0323 3246 |
| | Monticello to Vaca. | | | | | | 4. 5220 7261 |
| 14. | Mount Tamalpais. | 18 23 19. 328 | −0. 429 | 18. 899 | 1. 607 | 17. 292 | 0. 5010 6594 |
| | Monticello. | 39 38 43. 916 | +0. 139 | 44. 055 | 1. 607 | 42. 448 | 9. 8048 4153 |
| | Vaca. | 121 58 01. 649 | +0. 219 | 01. 868 | 1. 608 | 00. 260 | 9. 9285 7792 |
| | | | | | 4. 822 | | |
| | Mount Tamalpais to Vaca. | | | | | 67294. 58 | 4. 8279 8008 |
| | Mount Tamalpais to Monticello. | | | | | 89478. 04 | 4. 9517 1647 |
| | Mount Helena to Monticello. | | | | | | 4. 5863 3473 |
| | Mount Tamalpais. | 25 30 07. 828 | −0. 005 | 07. 823 | 2. 699 | 05. 124 | 0. 3659 9303 |
| 15. | Mount Helena. | 86 57 41. 069 | +0. 295 | 41. 364 | 2. 700 | 38. 664 | 9. 9993 8871 |
| | Monticello. | 67 32 18. 853 | +0. 059 | 18. 912 | 2. 700 | 16. 212 | 9. 9657 3403 |
| | | | | | 8. 099 | | |
| | Mount Tamalpais to Monticello. | | | | | 89478. 04 | 4. 9517 1647 |
| | Mount Tamalpais to Mount Helena. | | | | | 82806. 00 | 4. 9180 6179 |

* This triangle is of no practical value.

*Triangle-side computation*—Continued.

| | Stations. | Observed angles. | Corrections. | Spherical angles. | Spherical excess. | Plane angles and distances. | Logarithms. |
|---|---|---|---|---|---|---|---|
| | | ° ′ ″ | ″ | ″ | ″ | | |
| | Mount Helena to Vaca. | | | | | | 4. 7627 5783 |
| 16. | Mount Tamalpais. | 43 53 27. 156 | −0. 434 | 26. 722 | 3. 269 | 23. 453 | 0. 1590 9500 |
| | Mount Helena. | 53 40 13. 041 | +0. 925 | 13. 966 | 3. 269 | 10. 697 | 9. 9061 2725 |
| | Vaca. | 82 26 28. 554 | +0. 566 | 29. 120 | 3. 270 | 25. 850 | 9. 9962 0897 |
| | | | | | 9. 808 | | |
| | Mount Tamalpais to Vaca. | | | | | 67294. 58 | 4. 8279 8008 |
| | Mount Tamalpais to Mount Helena. | | | | | 82806. 00 | 4. 9180 6180 |
| | Mount Tamalpais to Mount Helena. | | | | | | 4. 9180 6179 |
| | Mount Diablo. | 49 47 50. 700 | −0. 597 | 50. 103 | 4. 192 | 45. 911 | 0. 1170 4767 |
| 17. | Mount Tamalpais. | 96 28 24. 920 | +0. 223 | 25. 143 | 4. 193 | 20. 950 | 9. 9972 2300 |
| | Mount Helena. | 33 43 57. 211 | +0. 120 | 57. 331 | 4. 192 | 53. 139 | 9. 7445 2821 |
| | | | | | 12. 577 | | |
| | Mount Diablo to Mount Helena. | | | | | 107728. 96 | 5. 0323 3246 |
| | Mount Diablo to Mount Tamalpais. | | | | | 60205. 71 | 4. 7796 3767 |
| | Mount Tamalpais to Monticello. | | | | | | 4. 9517 1647 |
| | Mount Diablo. | 69 51 21. 393 | −0. 054 | 21. 339 | 4. 310 | 17. 029 | 0. 0274 1654 |
| 18. | Mount Tamalpais. | 70 58 17. 092 | +0. 229 | 17. 321 | 4. 310 | 13. 011 | 9. 9755 9243 |
| | Monticello. | 39 10 34. 072 | +0. 198 | 34. 270 | 4. 310 | 29. 960 | 9. 8005 0466 |
| | | | | | 12. 930 | | |
| | Mount Diablo to Monticello. | | | | | 90100. 14 | 4. 9547 2544 |
| | Mount Diablo to Mount Tamalpais. | | | | | 60205. 71 | 4. 7796 3767 |
| | Mount Tamalpais to Vaca. | | | | | | 4. 8279 8008 |
| | Mount Diablo. | 70 07 50. 263 | +0. 366 | 50. 629 | 2. 724 | 47. 905 | 0. 0266 5687 |
| 19. | Mount Tamalpais. | 52 34 57. 764 | +0. 657 | 58. 421 | 2. 723 | 55. 698 | 9. 8999 4368 |
| | Vaca. | 57 17 18. 851 | +0. 269 | 19. 120 | 2. 723 | 16. 397 | 9. 9250 0073 |
| | | | | | 8. 170 | | |
| | Mount Diablo to Vaca. | | | | | 56830. 39 | 4. 7545 8063 |
| | Mount Diablo to Mount Tamalpais. | | | | | 60205. 71 | 4. 7796 3768 |

**The following four triangles (approximately adjusted) are given here with reference to remarks on standard latitude and azimuth, further on:**

| | Stations. | Observed angles. | Corrections. | Spherical angles. | Spherical excess. | Plane angles and distances. | Logarithms. |
|---|---|---|---|---|---|---|---|
| | | ° ′ ″ | ″ | ″ | ″ | | |
| | Mount Diablo to Mount Helena. | | | | | | 5. 0323 3246 |
| | Mount Lola. | 28 48 68. 349 | −0. 030 | 68. 319 | 19. 080 | 49. 239 | 0. 3169 865 |
| 20. | Mount Diablo. | 73 06 32. 761 | −0. 326 | 32. 435 | 19. 080 | 13. 355 | 9. 9808 358 |
| | Mount Helena. | 78 04 76. 664 | −0. 177 | 76. 487 | 19. 081 | 57. 406 | 9. 9905 370 |
| | | | | | 57. 241 | | |
| | Mount Lola to Mount Helena. | | | | | 213872. 4 | 5. 3301 548 |
| | Mount Lola to Mount Diablo. | | | | | 218703. 6 | 5. 3398 560 |

*Triangle-side computation*—Completed.

| | Stations. | Observed angles. | Corrections. | Spherical angles. | Spherical excess. | Plane angles and distances. | Logarithms. |
|---|---|---|---|---|---|---|---|
| | | ° ′ ″ | ″ | ″ | ″ | | |
| | Mount Diablo to Mount Helena. | | | | | | 5.0323 3246 |
| | Round Top. | 27 47 26.404 | +0.504 | 26.908 | 17.045 | 09.863 | 0.3314 541 |
| 21. | Mount Diablo. | 97 31 65.474 | —0.457 | 65.017 | 17.045 | 47.972 | 9.9962 386 |
| | Mount Helena. | 54 41 18.960 | +0.250 | 19.210 | 17.045 | 02.165 | 9.9116 771 |
| | | | | | 51.135 | | |
| | Round Top to Mount Helena. | | | | | 229100.1 | 5.3600 252 |
| | Round Top to Mount Diablo. | | | | | 188566.1 | 5.2754 637 |
| | Mount Diablo to Mount Lola. | | | | | | 5.3398 560 |
| | Round Top. | 96 40 15.474 | +0.026 | 15.500 | 14.431 | 01.069 | 0.0029 468 |
| 22. | Mount Diablo. | 24 25 32.713 | —0.131 | 32.582 | 14.431 | 18.151 | 9.6164 224 |
| | Mount Lola. | 58 54 55.366 | —0.155 | 55.211 | 14.431 | 40.780 | 9.9326 610 |
| | | | | | 43.293 | | |
| | Round Top to Mount Lola. | | | | | 91038.5 | 4.9592 252 |
| | Round Top to Mount Diablo. | | | | | 188566.2 | 5.2754 638 |
| | Round Top to Mount Helena. | | | | | | 5.3600 252 |
| | Mount Lola. | 87 43 63.715 | —0.184 | 63.531 | 16.466 | 47.065 | 0.0003 410 |
| 23. | Round Top. | 68 52 49.070 | —0.478 | 48.592 | 16.467 | 32.125 | 9.9697 886 |
| | Mount Helena. | 23 23 57.704 | —0.427 | 57.277 | 16.467 | 40.810 | 9.5988 589 |
| | | | | | 49.400 | | |
| | Mount Lola to Mount Helena. | | | | | 213872.4 | 5.3301 548 |
| | Mount Lola to Round Top. | | | | | 91038.5 | 4.9592 251 |

The sides as here computed may advantageously be regarded as lines of alignment. These lines have the property that for every point in the line the vertical plane at that point passes, when produced, through the terminal points, or, in other words, the azimuthal difference, at any point, of the initial and terminal points is 180°. This line has, therefore, an advantage over the geodetic line, inasmuch as the first and last linear elements coincide in direction with the respective normal plane sections at the terminal points; hence the line of alignment enters directly into the *measures* of horizontal directions, whereas the geodetic line deviates abruptly from the normal section, generally by one-third of the angle* contained between the two plane sections, one vertical at the first station and passing through the opposite one, the other vertical at the opposite station and passing through the first.

*Formulæ for the computation of geodetic latitudes, longitudes, and azimuths sufficiently precise for sides of the largest triangles that may be directly measured.*

In Appendix No. 7, Coast and Geodetic Survey Report for 1884, are contained the formulæ and tables ordinarily employed in the Survey for the computation of geographical positions and their mutual azimuths. In the application of these formulæ seven-place logarithms are used, and the results obtained possess all needful precision, provided the length of side or distance between two

* The geodetic line supposed drawn between Lake Tahoe and the Colorado River station and forming part of the boundary between California and Nevada, is 404.7 statute miles, or 651.2 kilometres in length; for this line we have calculated the angle at the southern end between the plane vertical section and the initial element of the curve to be 0″.82 and the corresponding angle at the northern end to be 0″.73, the angular difference between the two sections being three times these amounts, respectively. Near the middle of the line these two plane sections pass each other at a distance of $1^{m}.829$, or very nearly 6 feet.

points does not much exceed 1°, or, roughly, 69 statute miles or 111 kilometres, and the formulæ may even be used up to 100 statute miles when moderate accuracy suffices. The primary triangulations of California, Nevada, and Utah are on so large a scale that a stricter expression for the numerical computation is demanded. Among the different solutions of the problem we prefer the one given by Lieutenant-Colonel Clarke,* which was employed in the computation of the larger triangles of the Ordnance Survey of Great Britain, and also in the computation of the verification and extension of the arc of the meridian at the Cape of Good Hope. The method is found convenient even without specially prepared tables, such as accompany the Coast and Geodetic Survey formulæ, two of which tables, however, could be utilized if extended to 8 or 9 places of decimals; this number of decimals is demanded by the extended formulæ for the numerical logarithmic work. The surface of development is the spheroid, the dimensions of which were published by Clarke in 1866, and which was found to be more nearly conformable to the earth's figure (and to the surface of the United States in particular) than the Besselian spheroid previously employed.

Let $\varphi$, $\lambda$ be the latitude and longitude of the given point, $\alpha$ the azimuth and $s$ the distance to the second point, then the latitude $\varphi'$, the longitude $\lambda'$ and the reverse azimuth $\alpha'$ may be computed by the following formulæ:

$$\theta = \frac{s}{r \sin 1''} + \frac{e^2\,\theta^3 \sin^2 1''}{6\,(1-e^2)} \cos^2\varphi \cos^2\alpha$$

$$\zeta = \frac{e^2\,\theta^2 \sin 1''}{4\,(1-e^2)} \cos^2\varphi \sin 2\alpha$$

$$\tan\tfrac{1}{2}\,(\alpha' + \zeta - \Delta\lambda) = \frac{\sin\frac{1}{2}\,(\gamma-\theta)}{\sin\frac{1}{2}\,(\gamma+\theta)} \cot\frac{\alpha}{2}$$

$$\tan\tfrac{1}{2}\,(\alpha' + \zeta + \Delta\lambda) = \frac{\cos\frac{1}{2}\,(\gamma-\theta)}{\cos\frac{1}{2}\,(\gamma+\theta)} \cot\frac{\alpha}{2}$$

$$\varphi' - \varphi = \frac{s}{\rho \sin 1''} \cdot \frac{\sin\frac{1}{2}\,(\alpha'+\zeta-\alpha)}{\sin\frac{1}{2}\,(\alpha'+\zeta+\alpha)} \left[1 + \frac{\theta^2 \sin^2 1''}{12} \cos^2\tfrac{1}{2}\,(\alpha'-\alpha)\right]$$

The distance $s$ is the length of either of the *elliptic arcs* from the first to the second, or from the second to the first point, and differs only infinitesimally from a *line of alignment* and from a *geodetic line* between the same points. $r$ is the normal, extended to the minor axis, for the given point or latitude, or

$$r = \frac{a}{(1 - e^2 \sin^2\varphi)^{\frac{1}{2}}}$$

and $\rho$ is the radius of curvature of the meridian for the middle latitude $\frac{1}{2}\,(\varphi + \varphi^1)$ or

$$\rho = \frac{a\,(1-e^2)}{(1 - e^2 \sin^2\varphi)^{\frac{3}{2}}}$$

(see our factors A and B, report of 1884). $\theta$ is the angle subtended at the foot of the normal or axis by the curve $s$ and it suffices for most distances, unless extremely great, to put

$$\theta = \frac{s}{r \sin 1''},$$

the second term in the expression of $\theta$ being very small. The angle $\zeta$, also, is always a small quantity. We put $\gamma = 90° - \varphi$, the colatitude, and $\Delta\lambda = \lambda' - \lambda$, the difference of longitude. The azimuthal angles $\alpha$ and $\alpha' + \zeta$ are those within the polar triangle the solution of which is contained in the third and fourth of the given expressions and these angles are readily changed to conform to the azimuths of the line as usually reckoned in the direction from the south meridian westward to 360°. If $s_0$ be the length of an arc whose amplitude is $\mu$ and whose radius of curvature for the

* See his work on Geodesy, Oxford, 1880, but in particular the Ordnance Survey of Great Britain, London, 1858

middle point (mean between the terminal points) is $\rho_0$ then with greater precision than in the above formulæ

$$\mu = \frac{s_0}{\rho_0} - \left(\frac{\mu}{2}\right)^3 e^2 \cos 2\,\varphi$$

but this term in $e^2$ will seldom come into use. Using 8 places in the logarithms, $\triangle\,\varphi$ and $\triangle\,\lambda$ may be stated to 3 places of decimals in the seconds, with 9 place logarithms one place further may be had.

For convenience of reference we add the following constants and their logarithms:

| | | |
|---|---|---|
| $a = 6378206^{m}.4$ | [6.80469857] | $a : b = 294.98 : 293.98$ |
| $b = 6356583^{m}.8$ | [6.80322378] | |
| $e^2 = \frac{a^2 - b^2}{a^2} = 0.0067686580$ | [$\bar{7}$.83050257] | |
| $1 - e^2$ | [$\bar{9}$.99705042] | |
| $a(1 - e^2)$ | [6.80174898] | |
| $\frac{e^2 \sin^2 1''}{6(1 - e^2)}$ | [$\bar{\bar{6}}$.42645] | |
| $\frac{e^2 \sin 1''}{4(1 - e^2)}$ | [$\bar{1}$.91697] | |
| $\frac{\sin^2 1''}{12}$ | [$\bar{\bar{8}}$.29197] | |
| $\sin 1''$ | [$\bar{4}$.68557487] | |

For the longest line in the Yolo base-figure, Mount Helena to Mount Diablo, the difference in the results by the two methods, and when 8 place logarithms are employed in the computation is just appreciable, viz, in latitude 0''.001, in longitude 0''.003, and in azimuth 0''.002

There remains the computation of the geographical position of each point; for this purpose we need a standard geodetic latitude $\varphi_0$, a standard geodetic azimuth $\alpha_0$, and the introduction of the telegraphic longitude $\lambda$, there being but one station.

*Determination of standard geodetic data for the computation of geographical positions.*

Including the stations Mount Lola and Round Top, which are the easternmost points of the Davidson quadrilaterals, we have nine stations, at each of which the latitude and azimuth were determined astronomically, and we shall take the mean results derived from all of these observations for the formation of the standard values $\varphi_0$ and $\alpha_0$.

The direct results of the astronomical observations for latitude require two corrections—one the reduction to the station point △, the other the correction for curvature of the vertical or the reduction to the sea-level. The heights required for the latter purpose are given in Appendix No. 10, Coast and Geodetic Survey Report for 1884 (Mount Lola being 2796.4 *m*, or 9175 feet, and Round Top 3173.5 *m*., or 10412 feet high). For the expression of the curvature between the sea level and the altitude of the station we have (see Clarke's Geodesy, pp. 101–102)

$$\delta\varphi = -\frac{h}{r \sin 1''}\left(\frac{5}{2}m - e'\right)\sin 2\varphi$$

Putting

$$\frac{5}{2}m - e' = 0.0052^{*} \quad \text{and} \quad \log\,(r \sin 1'') = 1.490$$

then for $h$ the height in metres, and $\delta\varphi$ the correction in seconds, we have for the latitude $\varphi$

$$\delta\varphi = -\,.000167\,h \sin 2\varphi \quad \text{or} \quad [_{n}6.212]\,h$$

for the average latitude 39°, the number within brackets being a logarithm.

*G. Zachariae, in his Principal Geodetic Points (German translation by Dr. Lampe, Berlin, 1878), prefers the value 0.00513

*Geodetic or standard latitude, $\varphi_0$ of Mount Helena, for the Davidson quadrilaterals.*

| No. | Astronomical station. | Year of observation. | Observed astronomical latitude. | Probable error. | Reduction to △'n station. | Reduction to sea-level. | Resulting seconds of latitude. A. | Adopted geodetic latitude. G. | A — G. |
|---|---|---|---|---|---|---|---|---|---|
| | | | ° ′ ″ | ″ | ″ | ″ | ″ | ° ′ ″ | ″ |
| 1 | Southeast Yolo Base. | 1880 | 38 31 34.52 | ±0.06 | —0.45 | —0.00 | 34.07 | 38 31 35.41 | —1.34 |
| 2 | Northwest Yolo Base. | 1880 | 38 40 37.34 | ±0.07 | —0.13 | —0.01 | 37.20 | 38 40 38.03 | —0.83 |
| 3 | Monticello. | 1880 | 38 39 46.51 | ±0.09 | —0.31 | —0.15 | 46.05 | 38 39 43.85 | +2.20 |
| 4 | Vaca. | 1880 | 38 22 23.38 | ±0.06 | +0.37 | —0.12 | 23.63 | 38 22 27.02 | —3.39 |
| 5 | Mount Diablo. | 1876 | 37 52 49.59 | ±0.06 | 0.00 | —0.19 | 49.40 | 37 52 48.70 | +0.70 |
| 6 | Mount Tamalpais. | 1882 | 37 55 19.04 | ±0.08 | —0.04 | —0.13 | 18.87 | 37 55 20.69 | —1.82 |
| 7 | Mount Helena. | 1876 | 38 40 01.02 | ±0.06 | +0.47 | —0.22 | 01.27 | 38 40 04.26 | —2.99 |
| 8 | Mount Lola. | 1879 | 39 25 57.98 | ±0.06 | —0.22 | —0.46 | 57.30 | 39 25 53.34 | +3.96 |
| 9 | Round Top. | 1879 | 38 39 46.89 | ±0.08 | +0.01 | —0.52 | 46.38 | 38 39 43.64 | +2.74 |
| | | | | | | | | Mean. | —0.09 |

The mean difference A — G is small, approximating to zero, as it should do. We therefore retained and adopted for the present $\varphi_0$ for Mount Helena, 38° 40′ 04″.26, with a probable uncertainty of ± 0″.59 The average local deflection in the meridian is about 2″.2

*Geodetic or standard azimuth, $\alpha_0$ of direction Mount Helena to Mount Diablo, for the Davidson quadrilaterals.*

| No. | Station occupied. | To station observed. | Observed astronomical azimuth. | Probable error. | Reduction to sea-level. | Resulting seconds of azimuth. A′. | Adopted geodetic azimuth. G′. | A′ — G′. |
|---|---|---|---|---|---|---|---|---|
| | | | ° ′ ″ | ″ | ″ | ″ | ° ′ ″ | ″ |
| 1 | Southeast Yolo Base. | Northwest Yolo Base. | 163 07 13.51 | ±0.18 | — .00 | 13.51 | 163 07 15.07 | —1.56 |
| 2 | Northwest Yolo Base. | Southeast Yolo Base. | 343 05 02.35 | ±0.16 | — .00 | 02.35 | 343 05 04.03 | —1.68 |
| 3 | Monticello. | Mount Helena. | 91 04 25.16 | ±0.21 | — .00 | 25.16 | 91 04 23.79 | +1.37 |
| 4 | Vaca. | Southeast Yolo Base. | 235 38 36.44 | ±0.28 | + .00 | 36.44 | 235 38 33.47 | +2.97 |
| 5 | Mount Diablo. | Mount Helena. | 144 28 16.13 | ±0.15 | --- | 16.13 | 144 28 15.06 | +1.07 |
| 6 | Mount Tamalpais. | Mount Diablo. | 274 15 15.39 | ±0.14 | — .01 | 15.38 | 274 15 15.71 | —0.33 |
| 7 | Mount Helena. | Mount Diablo. | 324 01 24.86 | ±0.19 | --- | 24.86 | 324 01 31.04 | —6.18 |
| 8 | Mount Lola. | Mount Helena. | 67 21 62.57 | ±0.17 | — .16 | 62.41 | 67 21 59.55 | +2.86 |
| 9 | Round Top. | Mount Helena. | 90 58 53.67 | ±0.13 | — .16 | 53.51 | 90 58 53.01 | +0.50 |
| | | | | | | | Mean. | —0.11 |

The mean difference is sufficiently near to 0 to make it desirable to retain for the present the old value, and we adopt for the present $\alpha_0$, Mount Helena to Mount Diablo, 324° 01′ 31″.04 ± 0″.64

This value will slightly change after Mount Lola and Round Top shall have been finally adjusted. The average local difference in azimuth is about 2″.1

At the stations Mount Diablo and Mount Helena the astronomical azimuths were referred to a *mark*, and not to a triangulation point, and the same is the case at Mount Lola and Round Top. The reference to these stations in the preceding table would therefore be in a measure arbitrary, since the value must depend on the adjustment of the directions of the figure, but by applying a correction which is the mean of all corrections to the lines at the station the reference of the astronomical meridian to the geometrical figure of the triangulation is effected with respect to all the directions; thus, for the two stations in question:

At Mount Diablo:

| | ° ′ ″ |
|---|---|
| Observed azimuth of mark (Clayton), 9° 42′ 25″.92 W. of N. ± 0″.10; | |
| hence astronomical azimuth of mark ........................ | 170 17 34.08 |
| and, when reduced to the sea-level ........................ | 170 17 34.07 |

| | ° ′ ″ |
|---|---|
| At Mount Diablo the mean correction to the 6 adjusted directions is + ″.023 (± .11); this, added to the observed geodetic direction of the azimuth mark (25° 49′ 17″.194), gives (see table below) ........................ | 25 49 17.217 |
| Hence, with the corrected direction to Mount Helena (see below) ... | 359 59 59.273 |
| the angle between the mark and Mount Helena, adjusted .......... | 25 49 17.94 |
| And the astronomical azimuth referred to Mount Helena becomes, as given in the preceding table ........................ | 144 28 16.13 |
| Similarly at Mount Helena: | |
| Observed azimuth of mark (Woods) 9° 18′ 14″.36 E. of N. ± 0″.14 .. | 189 18 14.36 |
| Same reduced to sea-level ........................ | 189 18 14.37 |
| Mean correction to 4 adjusted directions at station — .″032 (± .13): | |
| Angle between the mark and Mount Diablo, adjusted ......... | 225 16 49.62 |
| Astronomical azimuth referred to Mount Diablo .............. | 324 01 24.86 |

as given in the preceding table.

We have also the following table of adjusted directions at these two stations:

| At Mount Diablo. Directions to— | Result of station adjustment. | Corr'n. Figure adjustment. | Final seconds. | At Mount Helena. Directions to— | Result of station adjustment. | Corr'n. Figure adjustment. | Final seconds. |
|---|---|---|---|---|---|---|---|
| | ° ′ ″ | ″ | ″ | | ° ′ ″ | ″ | ″ |
| Mount Helena. | 359 59 59.918 | —.645 | 59 273 | Mount Diablo. | 359 59 59.927 | +.183 | 60.110 |
| Monticello. | 20 03 30.611 | —.102 | 30.509 | Mount Tamalpais. | 33 43 57.138 | +.303 | 57.441 |
| Vaca. | 20 19 59.481 | +.319 | 59.800 | Azimuth mark (Woods). | 225 16 49.650 | | (49.618) |
| Azimuth mark (Clayton). | 25 49 17.194 | | (17.217) | Monticello. | 306 46 16.069 | +.008 | 16.077 |
| Northwest Base. | 38 39 09.129 | +.086 | 09.215 | Vaca. | 340 03 44.097 | —.621 | 43.476 |
| Southeast Base. | 43 24 20.921 | +.524 | 21.445 | | Mean. | —.032 | |
| Mount Tamalpais. | 310 12 09.218 | —.047 | 09.171 | | | | |
| | Mean. | +0.023 | | | | | |

**Tables of resulting adjusted directions were prepared for all stations, since the respective mean corrections are to be applied to all other subordinate directions not yet adjusted before they can be submitted to the process of the next figure adjustment, which ordinarily is of a secondary character.**

For the standard longitude of the triangulation about the Yolo Base we have to retain, at present, the telegraphic longitude of San Francisco, station at Washington square, viz: $\lambda = 8^h\ 09^m\ 38^s.34$, see Coast and Geodetic Survey Report for 1884, Appendix No. 11, p. 424, and derive from it for Mount Helena the value $\lambda_0 = 122^\circ\ 38'\ 01''.41$

These geodetic data, $\varphi_0$, $\alpha_0$, $\lambda_0$, are subject to changes hereafter, but generally standard data are best retained, and the small corrections noted, so long as the changes do not exceed the respective probable errors of these quantities. The resulting geodetic positions are appended.

The above is respectfully submitted by

CHAS. A. SCHOTT,
*Assistant, in charge Computing Division.*

*Geodetic results of the Davidson quadrilaterals, introducing the Yolo Base into the Primary Triangulation of California.*

**VICINITY OF YOLO BASE, CALIFORNIA.**

[Developed on the Clarke spheroid of 1866.]

| Stations. | Latitude. | Seconds in metres. | Longitude. | Seconds in metres. |
|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | |
| Mount Helena. | 38 40 04.260 | 131.4 | 122 38 01.410 | 34.1 |
| Mount Diablo. | 37 52 48.700 | 1501.4 | 121 54 51.948 | 1269.7 |
| Vaca. | 38 22 27.016 | 833.0 | 122 05 05.607 | 136.1 |
| Monticello. | 38 39 43.848 | 1352.0 | 122 11 25.961 | 627.7 |
| Southeast Yolo Base. | 38 31 35.408 | 1091.8 | 121 48 02.176 | 52.7 |
| Northwest Yolo Base. | 38 40 38.026 | 1172.5 | 121 51 32.220 | 778.9 |
| Mount Tamalpais. | 37 55 20.689 | 637.8 | 122 35 48.774 | 1191.3 |
| Round Top. | 38 39 43.636 | 1345.5 | 120 00 04.997 | 120.8 |
| Mount Lola. | 39 25 53.342 | 1645.0 | 120 21 55.496 | 1327.3 |

| From station. | Azimuth. | Back azimuth. | To stations. | Distance. | Logarithms. |
|---|---|---|---|---|---|
| | ° ′ ″ | ° ′ ″ | | *Metres.* | |
| Mount Diablo. | 144 28 15.065 | 324 01 31.040 | Mount Helena. | 107728.96 | 5.0323 3246 |
| Vaca. | 124 25 44.948 | 304 05 14.405 | Mount Helena. | 57910.57 | 4.7627 5783 |
| | 344 41 56.708 | 164 48 15.590 | Mount Diablo. | 56830.39 | 4.7545 8063 |
| Monticello. | 343 53 20.825 | 163 57 17.696 | Vaca. | 33271.52 | 4.5220 7261 |
| | 91 04 23.793 | 270 47 47.007 | Mount Helena. | 38577.56 | 4.5863 3473 |
| Southeast Base. | 55 49 09.875 | 235 38 33.468 | Vaca. | 30029.78 | 4.4775 5212 |
| | 114 01 51.300 | 293 47 15.614 | Monticello. | 37160.80 | 4.5700 8501 |
| Northwest Base. | 343 05 04.028 | 163 07 15.075 | Southeast Base. | 17486.512 | 4.2427 0319 |
| | 86 47 25.767 | 266 34 59.882 | Monticello. | 28906.93 | 4.4610 0196 |
| Mount Tamalpais. | 221 40 17.291 | 41 59 15.828 | Vaca. | 67294.58 | 4.8279 8008 |
| | 274 15 15.712 | 94 40 24.961 | Mount Diablo. | 60205.71 | 4.7796 3767 |
| Round Top. | 90 58 53.01 | 269 20 11.83 | Mount Helena. | 229100.1 | 5.3600 252 |
| Mount Lola. | 339 37 56.02 | 159 51 41.60 | Round Top. | 91038.53 | 4.9592 252 |

# APPENDIX No. 10.

## ON GEODETIC RECONNAISSANCE.

By CHARLES O. BOUTELLE, Assistant.

The accompanying memoir on Reconnaissance is intended to supply such information as my long experience suggests on a subject not fully treated in any text-book on Geodetic Surveying which has come under my notice.

It is not intended to supersede any portion of Appendix No. 9, Report of 1882, on the field work of the triangulation, but rather to enlarge and illustrate that portion of it which treats of Reconnaissance, by examples drawn from actual cases occurring in the usual routine, and by bringing out very fully the principles, theoretical and practical, which should govern in carrying on this very difficult, responsible, and laborious portion of Coast and Geodetic Survey duty. No department of professional labor calls for the exercise of a higher order of ability, or better repays thorough execution.

### RECONNAISSANCE.—PRIMARY TRIANGULATION AND BASE LINES.

Primary triangulation over any extended geographical area should be so laid out and conducted that its results should approach as near to absolute precision as the present condition of scientific research, theoretical, instrumental, and practical, will permit. No refinement in observation or reduction should be omitted which it is possible to supply. It should start from a *Base* so selected as to ground as to present the fewest natural obstacles to the passage of apparatus of the most delicate nature over every part of it. The length of this base should not be less than from eight to twelve kilometers, while its direction and terminals should be so selected as to admit of the formation upon it of triangles of gradually increasing sides, as the configuration of the surrounding country may admit.

### OF BASE LINES.

The terminals of a base line need not of necessity be intervisible from the ground, provided they can be rendered so from elevations of twelve to twenty meters. At no one of the primary bases of the Coast Survey at Bodie's Island, North Carolina, at Edisto Island, South Carolina, at Epping, Me., or at the Atlanta Base, were the termini intervisible from the ground.

While the nearest approach to a level plain is decidedly the most favorable for a base line, it is not an essential.

In the earlier bases measured in the Southern States near the ocean, small grades were always to be had, and the number of level planes largely predominated; but at the Epping Base, in Maine, measured in 1857, gradients of 1 in 20, or of an angular value of 3°, were adopted with entire success. In 1872, when prolonged search in the vicinity of Atlanta, Ga., developed only greatly undulating surfaces, a base-line was finally selected, with gradients as large as 5°, or 1 in 11.5. This base, which was 9.3 kilograms in length, was divided into no less than 270 different planes, ranging in their slopes from level to 5°. It was measured three times, and the apparatus upon the second measure was carried in the opposite direction to that of the first and third, so that ascending slopes upon the first were descending slopes upon the second, yet the accord of the two measures was so nearly perfect as to demonstrate that the apparatus could be well and safely used upon so diversified a surface. With the new primary-base apparatus, used at the Yolo Base, in California, the maximum grade was slightly greater, or 5° 21′. At this base, also, two measurements were made in opposite directions, with the same result.

In both these bases small sharp hollows were crossed upon trestle-work, which in former bases had been considered inadmissible. Embankments of crib-work were also used to advantage at Epping in 1857 and at the Atlanta Base in 1873.

These points will be useful in searching for future base lines, and will enable the observer to pay greater attention to the base connections, both in respect to geometric conditions and to gradual development. Examples of the best forms of such connections may be seen upon sketch No. 3, accompanying the Coast and Geodetic Survey Annual Report for 1884. The first primary base of the survey was measured by Mr. Hassler in 1834, near the sea-beach of Fire Island. It was liable to be destroyed by the encroachment of the sea upon the land, and it was ingeniously transferred from the "Measured Base" to the Interior or "Mountain Base" upon Long Island, extending from "West Hills" to "Ruland" by a quadrilateral of good proportions, whence another quadrilateral, with gradually increasing sides, carries the system across Long Island Sound to another longer side from "Wooster" to Sandford, and furnishes bases for extending the reticulation in both directions along the coast and also into the interior.

Another example of base connection, having every element of geometrical precision which could be asked for, may be seen upon the same sketch, at the Epping Base, in Maine, where the terminals connect with the three subsidiary stations, "Burke," "Pigeon," and "Tunk," and gradually enlarge the sides to the dimensions of the primary triangulation. Still another example of gradual expansion, through quadrilaterals, may be seen upon sketch No. 11, Report for 1884, where the measured "Yolo Base" is carried in two quadrilaterals of good shape from the plain to the mountain summits.

### RECONNAISSANCE FOR STATIONS OF A PRIMARY TRIANGULATION.

With bases measured and the base-connection established, the next step is a reconnaissance for the extension of the primary triangulation by the selection of the most suitable points in the proposed system of triangles.

Certain general principles must of necessity govern this work, which is one requiring the exercise of skill and good judgment combined with readiness in the application of geometric principles in the most varied forms of practical application to surveys over large areas.

These principles are—

(1) Primary triangulation should be carried on with the fewest possible number of stations which the configuration of the country will allow, and at the same time preserve the highest order of precision. This is best attainable by a system of quadrilaterals with every point intervisible; and next by a system of hexagons or pentagons where each exterior point sees a central interior station but does not necessarily see every other exterior point.

(2) Primary stations should occupy crests of ridges, or the highest accessible summits of mountain ranges. This is especially necessary in the United States, whose population and resources are so rapidly increasing. Although the particular object of the work in hand may be simply to connect certain points more or less distant by a geodetic chain, yet in a few years that very chain may of necessity be enlarged in every direction to meet demands for more precise interior surveys. If the highest summits are chosen at first, even at greater first cost of time, labor, and money, then when the time arrives (as it surely will) for extending surveys in new directions the old bases will be the best possible under all circumstances.

The writer desires to especially impress this point upon future observers, who will be tempted, as he has been (and too often yielded), into selection of some point, not a crest but near one, convenient of access, cleared of forest timber, and filling every condition needed for the work immediately in hand. I cite one case to show how this has cost largely in the end.

In 1845 a primary triangulation was laid out to connect Washington with the Kent Island base, near Annapolis. A point, "Soper" (see sketch 4, Coast Survey Report of 1874), was chosen because it involved lines of least cutting for connection with stations in and near the capital city, and could be occupied, at small cost, without elevation of the 30-inch theodolite which was used at the station.

In 1868 the attempt to carry a chain of primary triangles through the flat and densely wooded country close upon the seaboard, south of the Chesapeake, was abandoned, and it was decided to continue the chain which then extended from New Brunswick to Virginia, along the first range of hills parallel to the sea-coast, which was the origin of the "Blue Ridge triangulation." It was attempted to use the work already executed upon Washington and above referred to; but careful reconnaissance developed the fact that the station Soper could not be made to look westerly, while only 3 miles northwest of it was a ridge nearly 100 feet higher, which commanded the entire country in every direction, and was the crest between the Chesapeake and Potomac. To remedy the mistake of 1845 in the later work cost the Coast Survey several thousand dollars. This is one of many such cases.

(3) In the older works upon geodesy 30° is prescribed as the smallest admissible angle in a primary chain. But since the date of most of these works the degree of attainable precision in the observations of directions has been largely increased, until the probable error of an observed direction in primary triangulation now rarely exceeds $0''.2$, and a change of $0''.5$ in each angle of a triangle so badly shaped that one angle should be 125° and the other (opposite the base) only 15° would cause a change in the resulting sides of $0^{m}.07$ for each 10 kilometers of length, and this difference would be largely reduced in the adjustment of any system of quadrilaterals of which such a triangle would form a part. While, therefore, the greatest care should be taken to obtain only "well-conditioned" triangles, yet the only case where the rule of nothing less that 30° should be rigidly adhered to is the case of a single chain admitting of no check between measured bases.

(4) An essential point in reconnaissance is the determination beyond the possibility of doubt of the intervisibility of every primary line essential to the scheme. This is often a very difficult and doubtful matter where the lines of sight are from 60 to 120 kilometers in length, and the weather is thick and hazy. Patient waiting for absolute certainty, however annoying or vexatious, or whatever hardship it may entail, is better than to allow any doubt to cloud reported results and perhaps cause serious delay and loss of time, which is money, to the observers who will succeed the reconnoitering party.

(5) Permanence of position for primary stations is an object to be carefully looked to, especially near the sea-coast where inroads of the ocean are possible, or in places where excavations may be made or buildings erected. In addition to the usual underground and surface marks, a round of angles upon prominent near objects, natural and artificial, will often serve to recover and identify a long disused station.

Not many years ago the writer had occasion to recover a primary station upon the island of Nantucket, originally made a quarter of a century before, by an assistant many years deceased. He was conducted by two residents of the island to the "exact site" of the former signal.

He had with him the original description, accompanied with angles upon certain churches and light-houses, of which four, he was informed, were the same he now beheld. On setting up his instrument and observing the angles he at once saw and said to the venerable men who had accompanied him that their memories were at fault. That was not the hill on which the station had been made. They scouted the idea of a mistake on their part, and were indignant that a stranger should be better informed than they who had spent their lives near the place. Paying no further attention to them, the instrument was removed to another ridge about a third of a mile distant. where, after half an hour of tentative observation, he directed his men to dig for the underground mark placed there 25 years ago, which they quickly discovered within 3 feet of the place he had indicated, to the unconcealed astonishment and mortification of his well-meaning but mistaken informants. This incident emphasizes the fact that the recorded description of the station, *without the observed angles*, would not have sufficed to recover the station, since the external aspect of the two hills was very much alike.

Assuming that geodetic surveys will, sooner or later, be extended over every part of the vast territory of the United States, it is of the highest importance that each triangulation point shall be so marked, and the record of the marking made so clear and definite, that the exact site may be recoverable during succeeding centuries. Topographical features may change with advancing population and wealth. New maps will be wanted. They may be quickly and readily supplied if only the old trigonometrical stations, or a part of them, may be reproduced. At this moment a new topographical survey of the State of Massachusetts is in progress. No new great triangulation is necessary, for enough of the triangulation of 1832 to 1840 is found to furnish bases for supplying the new secondary and tertiary points required. For a more detailed description of methods of marking stations, see Appendix No. 9, Report for 1882, "Field work of the Triangulation," pages 159 and 160. Thus the officer making the reconnaissance for a triangulation should bear in mind, in selecting and making his stations, that his work is not for an immediate present purpose only, but that it may furnish bases for future centuries.

Primary triangulation presents different phases and encounters widely varied difficulties, depending upon the character of the country it traverses. Of these are—

1. Triangulation across bays and lakes, like Delaware or Chesapeake Bays.
2. Over open country, nearly level, as upon prairies.
3. Over a comparatively level farming country, partially wooded.
4. Over a hilly and wooded country, with parallel ridges of nearly the same elevation.
5. Over a hilly or mountain country, with elevations of irregular height.

Taking these up in the order named, the first brings up at once the limitations of lengths of sides, depending on the elevations to be found on each side of the bay or lake. Here it is important to consider a point essential to precision of observation. It is that no primary line, across water, or over a level country, should approach nearer than ten feet to the surface of the point where the line of sight becomes tangent to the curve of the earth's surface. It is apt to encounter a disturbed stratum of air very likely to deflect it laterally as well as vertically, as also very difficult to see through. Where the elevations of the two stations above the water between them, and their distance from each other, are approximately known, the question of their intervisibility may be quickly solved by an application of the following rule, which is easy to remember: It assumes a coefficient of refraction = 0.07. The curvature (and refraction combined) in feet is five hundred and seventy-four thousandths of the square of the distance in statute miles, or $Cf = 0.574\ Dm^2$, and reciprocally $Dm = \sqrt{\frac{Cf}{0.574}}$: To apply this in practice, the distance from Egg Shoal to Long Shoal Point, near Cape Hatteras (Coast and Geodetic Survey Report for 1884, Sketch No. 5), is 22.3 miles. Both stations are 12 feet above Pamplico Sound. What elevation will be required at each end to carry the line of sight 12 feet above the surface of the water? As the heights of the two stations are equal the line of sight will be tangent to the earth's curve at the midway point, or 11.15 miles from each end. The height required will therefore $= 0.574 \times 11.15^2 = 71.4$ feet. If now the signal at Egg Shoal be raised to a height of 90 feet above the ground, where will the line of sight become tangent to the curve, and what elevation will be required at Long Shoal Point?

The tangent point will be $\sqrt{\frac{90}{0.574}} = 12.52$ miles from Egg Shoal, or $22.30 - 12.52 = 9.78$ miles from Long Shoal Point, where the height required will be $0.574 \times 9.78^2 = 54.9$ feet. Therefore, a telescope 55 feet above the ground at either station will be sure to see a signal 90 feet above the ground at the other station, and the line of sight will be sure to pass at least 12 feet above the surface of the sound at the tangent point.

I give now an example of a different nature. In making the reconnaissance for extension of the primary triangulation across Massachusetts, it became important to make a station upon Cape Ann which should see Manomet Hill in Plymouth across Massachusetts Bay. A triangulation point of the Massachusetts State Survey, called Railcut Hill, had been found in that survey to be 205 feet above the sea, while Manomet Hill was 394 feet high. The distance between the two was 48.5 miles. Were they intervisible, or could they be easily be made so?

By the foregoing formula the "portee" or distance from Manomet to the tangent point was $= \sqrt{\frac{394}{0.574}} = 26.2$ miles. This left 22.3 miles for the remaining distance and $0.574 \times 22.3^2 = 285$ feet for the height required at Cape Ann. It was evident that a higher point than Railcut must be sought for. It was found at Thomson's Hill (Coast and Geodetic Survey Report, 1884, Sketch 3).

The general formula is: Curvature and refraction $= (1 - 2m)\frac{K^2}{2R}$ where R = mean radius of the earth; K = distance, and $m$ = coefficient of refraction. Log. R in feet may be taken as = 7.3199507, or in meters log. R = 6.8039618. The coefficient of refraction is assumed at 0.07 $m$, which represents its mean value in the horizon from a large number of observations both on the sea-coast and in the interior. If K is expressed in feet or meters, then for any distance

Log. curvature and refraction in feet = log. $K^2$ ft. + 2.31352.

Log. curvature and refraction in meters = log. $K^2$ m. + 2.82951.

The following tables represent the values of these quantities in feet for each mile of distance up to 80 miles, and for meters in each kilometer of distance up to 80 kilometers. The close approximation to truth of the rule first given may be seen by comparing its result with that of the table; $0.574 \times 80^2 = 3673.6$ feet, or within 1 foot of the tabular value for so great a distance as 80 miles. Its value in reconnaissance consists in its ready application on the ground, when away from log. tables and reference books:

*Tables of values of curvature and refraction.*

| Distances in miles, curvature and refraction in feet. | | | | | | | |
|---|---|---|---|---|---|---|---|
| M. | Feet. | M. | Feet. | M. | Feet. | M. | Feet. |
| 1 | 0.57 | 21 | 253.06 | 41 | 964.61 | 61 | 2135.23 |
| 2 | 2.30 | 22 | 277.74 | 42 | 1012.25 | 62 | 2205.60 |
| 3 | 5.17 | 23 | 303.56 | 43 | 1061.03 | 63 | 2277.52 |
| 4 | 9.19 | 24 | 330.53 | 44 | 1110.95 | 64 | 2350.40 |
| 5 | 14.35 | 25 | 358.64 | 45 | 1162.02 | 65 | 2424.43 |
| 6 | 20.66 | 26 | 387.90 | 46 | 1214.24 | 66 | 2499.61 |
| 7 | 28.12 | 27 | 418.31 | 47 | 1267.61 | 67 | 2575.93 |
| 8 | 36.73 | 28 | 449.87 | 48 | 1322.12 | 68 | 2653.40 |
| 9 | 46.49 | 29 | 482.59 | 49 | 1377.78 | 69 | 2732.01 |
| 10 | 57.40 | 30 | 516.46 | 50 | 1434.59 | 70 | 2811.77 |
| 11 | 69.46 | 31 | 551.47 | 51 | 1492.55 | 71 | 2892.68 |
| 12 | 82.66 | 32 | 587.62 | 52 | 1551.66 | 72 | 2974.74 |
| 13 | 97.00 | 33 | 624.92 | 53 | 1611.92 | 73 | 3057.95 |
| 14 | 112.49 | 34 | 663.36 | 54 | 1673.33 | 74 | 3142.31 |
| 15 | 129.12 | 35 | 702.94 | 55 | 1735.89 | 75 | 3227.83 |
| 16 | 146.90 | 36 | 743.67 | 56 | 1799.59 | 76 | 3314.49 |
| 17 | 165.83 | 37 | 785.55 | 57 | 1864.43 | 77 | 3402.29 |
| 18 | 185.92 | 38 | 828.59 | 58 | 1930.41 | 78 | 3491.23 |
| 19 | 207.15 | 39 | 872.78 | 59 | 1997.54 | 79 | 3581.32 |
| 20 | 229.53 | 40 | 918.12 | 60 | 2065.81 | 80 | 3672.55 |

| Distances in kilometers, curvature and refraction in meters. | | | | | | | |
|---|---|---|---|---|---|---|---|
| K. | Meters. | K. | Meters. | K. | Meters. | K. | Meters. |
| 1 | 0.07 | 21 | 29.78 | 41 | 113.53 | 61 | 251.30 |
| 2 | 0.27 | 22 | 32.69 | 42 | 119.13 | 62 | 259.60 |
| 3 | 0.61 | 23 | 35.73 | 43 | 124.87 | 63 | 268.05 |
| 4 | 1.08 | 24 | 38.90 | 44 | 130.75 | 64 | 276.63 |
| 5 | 1.69 | 25 | 42.21 | 45 | 136.76 | 65 | 285.34 |
| 6 | 2.43 | 26 | 45.65 | 46 | 142.90 | 66 | 294.19 |
| 7 | 3.31 | 27 | 49.23 | 47 | 149.18 | 67 | 303.17 |
| 8 | 4.32 | 28 | 52.95 | 48 | 155.60 | 68 | 312.29 |
| 9 | 5.47 | 29 | 56.80 | 49 | 162.15 | 69 | 321.54 |
| 10 | 6.75 | 30 | 60.78 | 50 | 168.84 | 70 | 330.93 |
| 11 | 8.17 | 31 | 64.90 | 51 | 175.66 | 71 | 340.45 |
| 12 | 9.72 | 32 | 69.16 | 52 | 182.61 | 72 | 350.10 |
| 13 | 11.41 | 33 | 73.55 | 53 | 189.71 | 73 | 359.90 |
| 14 | 13.23 | 34 | 78.07 | 54 | 196.93 | 74 | 369.82 |
| 15 | 15.19 | 35 | 82.83 | 55 | 204.29 | 75 | 379.89 |
| 16 | 17.29 | 36 | 87.53 | 56 | 211.79 | 76 | 390.09 |
| 17 | 19.51 | 37 | 92.46 | 57 | 219.42 | 77 | 400.42 |
| 18 | 21.88 | 38 | 97.52 | 58 | 227.19 | 78 | 410.89 |
| 19 | 24.33 | 39 | 107.72 | 59 | 235.09 | 79 | 421.49 |
| 20 | 27.01 | 40 | 108.06 | 60 | 243.13 | 80 | 432.23 |

***Values of curvature and refraction for short distances.***

| Distances in yards, curvature and refraction in feet. | | | | | |
|---|---|---|---|---|---|
| Yards. | Feet. | Yards. | Feet. | Yards. | Feet. |
| 50 | .0005 | 550 | .0560 | 1050 | .2042 |
| 100 | .0019 | 600 | .0669 | 1100 | .2241 |
| 150 | .0042 | 650 | .0783 | 1150 | .2450 |
| 200 | .0074 | 700 | .0908 | 1200 | .2668 |
| 250 | .0116 | 750 | .1042 | 1250 | .2895 |
| 300 | .0167 | 800 | .1186 | 1300 | .3131 |
| 350 | .0227 | 850 | .1339 | 1350 | .3376 |
| 400 | .0296 | 900 | .1501 | 1400 | .3631 |
| 450 | .0375 | 950 | .1672 | 1450 | .3895 |
| 500 | .0463 | 1000 | .1852 | 1500 | .4168 |

| Distances, curvature, and refraction in meters. | | | | | |
|---|---|---|---|---|---|
| Meters. | | Meters. | | Meters. | |
| Dist. | Curv. and Refr. | Dist. | Curv. and Refr. | Dist. | Curv. and Refr. |
| 50 | .0002 | 550 | .0204 | 1050 | .0744 |
| 100 | .0007 | 600 | .0243 | 1100 | .0817 |
| 150 | .0015 | 650 | .0285 | 1150 | .0893 |
| 200 | .0027 | 700 | .0331 | 1200 | .0972 |
| 250 | .0042 | 750 | .0380 | 1250 | .1055 |
| 300 | .0061 | 800 | .0432 | 1300 | .1141 |
| 350 | .0083 | 850 | .0488 | 1350 | .1231 |
| 400 | .0108 | 900 | .0547 | 1400 | .1324 |
| 450 | .0137 | 950 | .0609 | 1450 | .1420 |
| 500 | .0169 | 1000 | .0675 | 1500 | .1519 |

In an open level country, where no natural or artificial obstacles interfere, the triangulation may be laid out with reference only to the heights of structures erected and the geometrical conditions involved. If a uniform height above ground of 70 feet be assumed for the instrument and signal, and the line of sight is made to pass 10 feet above the surface at the tangent-point, a single series of nearly equilateral triangles with sides about 20 miles in length may be made. This would be the best system to adopt in a level wooded country where avenues are required on every line, as in a chain of triangles across the Florida Peninsula, where the triangulation starts from a base on the Atlantic side, to meet and be checked by another base upon the Gulf side. But in a level and open country a system of quadrilaterals with sides of about 15 miles and diagonals of 21 will only require one more station for every 30 miles of progress, and will more than gain this expense and labor in the additional precision acquired.

In a level country which is cultivated and where wood land is valuable, very careful reconnaissance is necessary to avoid striking insuperable obstacles, as houses and ornamental trees. If the country is intersected by navigable creeks, as upon the sea islands of South Carolina and Georgia, chains of secondary triangles along the water courses have proved the best resource. About ten years ago I planned a method of connecting the Atlanta and Edisto Bases, by extending a chain of triangles from near "Currahee" Station, in North Georgia, along the valley of the Savannah River, with stations upon the hills on each side as far as Augusta, where the "rolling country" ends, and thence by measurement upon the Augusta and Port Royal railroad, a distance of 80 miles, to a connection with the coast triangulation at Beaufort, S. C. This method of measurement was proposed by Assistant J. E. Hilgard in Appendix No. 9, Report for 1867. I have always considered it practicable upon railroads having only a slight percentage of curvature, where the direction may be carefully kept up by angular measurements and observed azimuths. The railroad here named has one straight line of 45 miles in length, which is half the whole distance to be measured.

In a hilly and wooded country, with parallel ridges of nearly the same elevation, the skill and resources of the reconnoitering officer are severely tried. A secondary triangulation may be easily laid out, since the sides may be carried from ridge to ridge across the intervening valleys. But the longer sides required for primary triangles must cross these wooded ridges at various angles, and to ascertain with certainty the intervisibility of distant points or the possibility of rendering them intervisible is often exceedingly difficult.

The best method is that of an approximate secondary triangulation with a gradienter or (if observations must be made from tops of trees) with a sextant, starting, of course, from some known base. A computation of approximate triangle sides, combined by linear co-ordinates from the meridian of the starting point and kept up as the reconnaissance progresses, will best develop both the possible triangles and the geometrical figure best suited to the ground. Approximate vertical angles will give differences of level close enough to decide on elevations likely to be needed to see over intervening ridges, and also to ascertain which are the highest crests of each ridge. Proceeding with care in this manner, it will be found that certain points are so situated, both in position, elevation, and accessibility, that they *must be* primary stations. Others again present equal advantages, and *may be* chosen, that is, some one of them may be, while others, which had appeared at the outset as very prominent from their abrupt and sharp elevation above the general level, fade into insignificance before long and gradual slopes, which finally overtop all others.

Keeping in mind the principle heretofore set forth, that "primary stations should occupy the highest crests," and patiently laboring to discover and identify what are the highest crests, it will be found, when these are discovered and connected by approximate linear co-ordinates, that they are susceptible of such linear connections as will, at least cost of time and money, develop into the best obtainable system of primary triangulation. Hence follow two rules for reconnaissance in such a difficult country as I am describing, viz: First, search for the crests or highest points of the highest ridges and connect them by an approximate series of small triangles from a known base. Second, endeavor to render the selected points intervisible by avenues across wooded intervening ridges, or by building high enough to see over them, or both combined. I would cite Northern Alabama as a notable example of the kind of country I have described.

Primary triangulation over a hilly or mountain country with isolated summits of unequal height will, as a rule, admit of the fewest possible number of stations with the longest possible sides, as in the great "Davidson" quadrilateral in California, where one diagonal is 143 miles long and the area of the quadrilateral is over 6,600 square miles. These great distances are not attainable east of the Rocky Mountains, as neither topographic nor atmospheric conditions admit of them; but the principle of the choice of the highest summits with the fewest possible number of stations has been carried out in the primary triangulation along the coast from Narragansett Bay to the Bay of Fundy, a distance of about 400 miles, covered by 9 quadrilaterals, or about 45 miles to each quadrilateral.

The conditions governing the choice of stations in the chain of triangles connecting the Kent Island and Atlanta Bases were of an entirely different character. The very level and densely wooded character of the sea-coast south of Chesapeake Bay forced the great chain of primary triangulation back to the first range of hills parallel to the coast, which was the Blue Ridge, and the plan adopted was to make the back tier of stations upon the Blue Ridge and the front tier nearest the coast upon the outlying foot-hills as far southeasterly as intervisible stations could be found. From these connecting chains of smaller triangles were to be made with the sea-coast bases at Bodies', Edisto, and Dauphin Islands. As a matter of necessity nearly every quadrilateral here took an elongated form, with the longer sides along the mountain ranges and parallel to the seaboard.

Omitting the smaller series required to reach the mountains from Annapolis, the distance of 602 miles between the two bases is covered by 16 quadrilaterals, having an average length of about 38 miles from each long side and 25 miles for the short side of each quadrilateral, with the longest side 82 miles and the shortest side 20 miles.

In this form of reconnaissance, as in that preceding it, the first step to be taken is a general examination of the country, fixing its most prominent features in the mind of the observer, most careful watch being kept of the different phases presented by the principal elevations as seen from different points of view. Here rapid outline sketches inserted in the note-book will be found of great service in identifying the same point under different aspects.

This general reconnaissance also helps in acquiring a habit of *self-orientation*, by which, on reaching a mountain summit, with an extended *coup d'œil*, the eye will at once recognize and correctly locate the most salient points of view.

This is followed by a close reconnaissance, with the advantage that certain points of special prominence have been recognized as belonging to the class of stations that *must be* taken, thus reducing the work to an examination of those which *may be* taken. As these must of necessity bear certain geometric relations to the "must-be" stations, the general region to be more carefully looked to is narrowed, and the work to be done more sharply defined.

The best method is that described on the preceding page. Start from a known base, and make an irregular approximate triangulation; that is, wherever a cleared hill presents itself which is accessible visit it and observe angles upon all prominent objects in sight. If no known station is visible, observe the magnetic meridian as a reference point. The best instrument for the purpose is the gradienter, which is light, small, and compendious, enabling one to get very good approximate elevations with its micrometer. Early in the work some of the points seen and observed from the known stations will be observed, and it will be possible to compute the positions of one or more of the points visited.

### THREE-POINT PROBLEM.

If only the positions may be known to within 150 meters, it will be sufficient to insure their presence within the field of view of the telescope if they are in sight. The "three-point" problem may be used to advantage if as many as three or more known points are approximately observed. Where the known positions are projected on a reconnoitering map, the position of the point of observation may be approximately ascertained by plotting the observed angle upon tracing muslin and fitting the three or more diverging lines to hit the observed station, as usual in hydrographic work, with the three-arm protractor. But where the position of the point is wanted in prolonging the reconnaissance, it may be computed. An example is here given.

At View Tree Mountain, near Warrenton, Va., the following angles were observed upon three known stations—Bull Run, Clarke, and Marshall. Required, the position of View Tree:

*At View Tree.*

| | ° ′ | | | Meters. | |
|---|---|---|---|---|---|
| 1. Bull Run = A = | 0 00 | Bull Run—Clarke | = c = | 68461 | log = 4.83544 |
| 2. Clarke = B = | 162 19 | Marshall—Clarke | = a = | 54435 | log = 4.73588 |
| 3. Marshall = C = | 243 30 | Marshall—Bull Run | = b = | 44916 | log = 4.65240 |

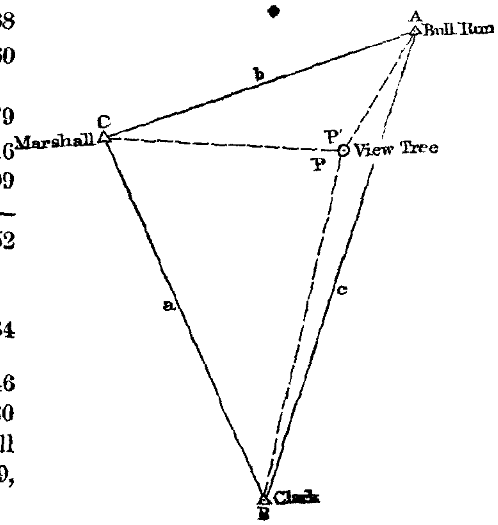
Formula of Reduction (1) $\cot X = \cot R \left( \frac{a \sin P'}{b \sin P \cos R} + 1 \right)$ (2) $Y = R - X$

Known angle ACB = C = 86° 33′ 4
Observed angle BPC = P = 81 11 0 and CP′A = 116° 30′ △ R = 360° − P − P′ − C = 75° 45′.6.

| | | |
|---|---|---|
| Marshall—Clarke = a = 54435 | | = 4.73588 |
| Marshall—Bull Run = b = 44916 | | co-ar = 5.34760 |
| P′ | = 116° 30′ | sin = 9.95179 |
| P | = 81 11 | co-ar sin = 0.00516 |
| R | = 75 45.6 | co-ar cos = 0.60909 |
| | + 4.4619 | = 0.64952 |
| | + 1. | |
| | 5.4619 | = 0.73734 |

| | ° ′ | |
|---|---|---|
| R = | 75 45.6 | cot = 9.40446 |
| cBP = X = | 35 48.5 | cot = 0.14180 |
| cAP′ = Y = | 39 57.1 | |
| PcB = | 63 00.5 | |

Whence the angles at Marshall are deduced and ACP′ = 23° 32′.9, and the sides may be computed as usual.



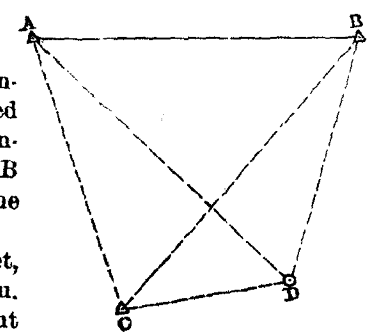

TWO-POINT PROBLEM.

It sometimes happens that only two triangulation points upon elevated peaks, difficult of access, are visible from a comparatively level and lower region where a reconnaissance is being made to find the best points to connect with them. Where any two lower hills see each other, and also the two higher stations, the direction and distance between which is known, the positions of the two unknown points may be determined, as follows: Let A and B represent the two known points, and C and D the two unknown ones.

At C measure ACB, ACD, BCD.

At D measure CDA, CDB, ADB.

Assume a length for the side CD and on this assumed base compute the triangles ACD and BCD; then, with two sides and included angle given, compute ACB and ADB. Having thus found the angles in the quadrilateral ABCD, substitute the true length of AB and re-compute the triangles, thus obtaining the true position of the points C and D.




Proceeding in this manner, from the known data at the outset, it will be possible in any country like that here described to accumulate approximate data which will enable the observer to lay out a scheme of triangulation best adapting itself to the configuration of the country while also best conforming to the requisite geometric conditions.

I have found the method of keeping up a system of linear co-ordinates so useful in this work, that I add examples of its prosecution and use. Instead of using the azimuths of the triangle sides observed I have used their angles with the assumed meridian for greater convenience of computation.

The example given is from a reconnaissance in Northern Alabama, to determine the best positions for the stations next west of the known stations, Wilson, Rowe, and Smithers; also, as the reconnaissance progressed, as to the possibility of rendering intervisible the point "Tanyard" from Wilson and Rowe. Rowe is made the starting point, and the directions from that point are angles with its meridian. All other directions are taken as angles with parallels to the meridian of Rowe. The distances are taken from computations of approximate triangles, which are here omitted.

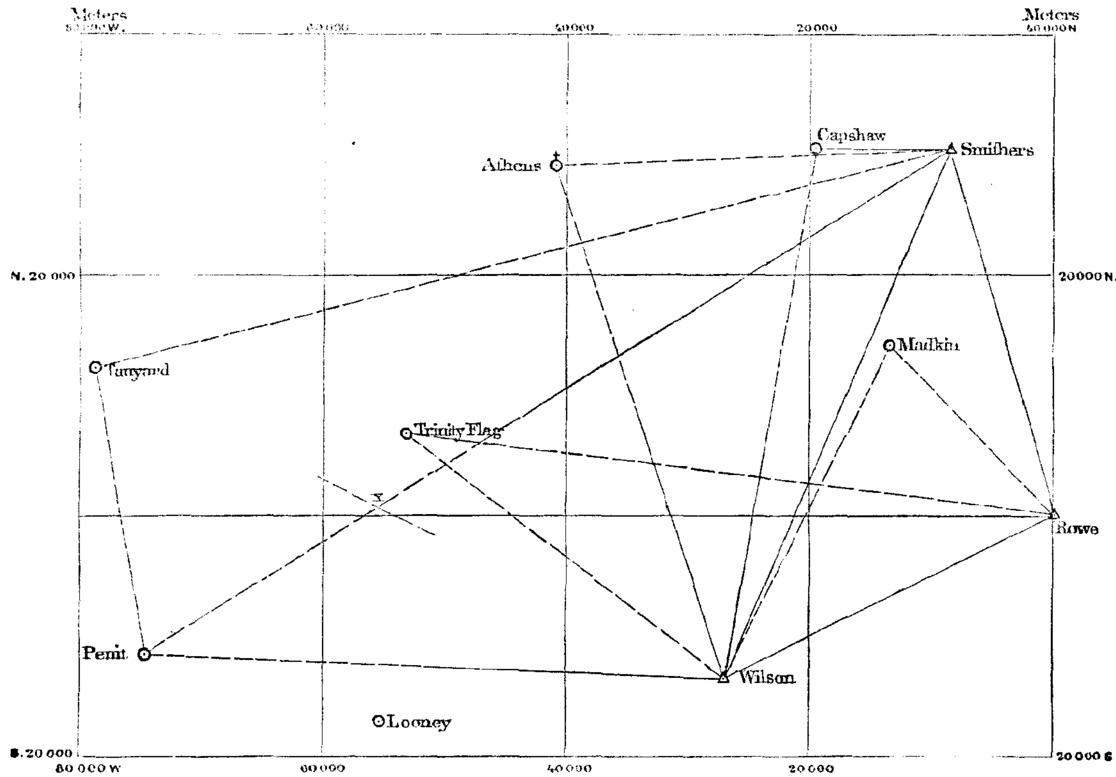
*Computation of linear co-ordinates.*

[D = directions. K = distances in meters.]

| From where to where. | | D | Log sin D | Log cos D | Log K | K cos D | Log K cos D | K sin D | Log K sin D |
|---|---|---|---|---|---|---|---|---|---|
| | | ° ′ ″ | | | | *Meters.* | | *Meters* | |
| Rowe to Smithers. | NW. | 15 20 48 | 9.42269 | 9.98423 | 4.50326 | 30725 | 4.48749 | 8432 | 3.92594 |
| Wilson. | SW. | 63 39 06 | 9.95236 | 9.64721 | 4.47857 | 13359 | 4.12578 | 26973 | 4.43093 |
| Capshaw. | NW. | 32 22 23 | 9.72870 | 9.92664 | 4.56335 | 30902 | 4.48999 | 19591 | 4.29205 |
| Madkin. | NW. | 37 43 57 | 9.78673 | 9.89811 | 4.25342 | 14175 | 4.15153 | 10969 | 4.04015 |
| Trinity Flag. | NW. | 82 25 34 | 9.99619 | 9.11993 | 4.72971 | 7073.5 | 3.84964 | 52199 | 4.72590 |
| Wilson to Trinity Flag. | NW. | 52 04 32 | 9.89698 | 9.78861 | 4.52173 | 20433 | 4.31034 | 26224 | 4.41871 |
| Madkin. | NE. | 30 10 00 | 9.70115 | 9.93680 | 4.50309 | 27535 | 4.43989 | 16004 | 4.20424 |
| Looney. | SW. | 82 13 30 | 9.99599 | 9.13124 | 4.46539 | 3950 | 3.59663 | 28932 | 4.46138 |
| Penit. | NW. | 87 25 14 | 9.99956 | 8.65326 | 4.67963 | 2152 | 3.33289 | 47774 | 4.67919 |
| Capshaw. | NE. | 9 28 10 | 9.21622 | 9.99404 | 4.65198 | 44261 | 4.64602 | 7382.5 | 3.86820 |
| Smithers. | NE. | 22 48 39 | 9.58848 | 9.96463 | 4.67965 | 44084 | 4.64428 | 18541 | 4.26813 |
| Athens church. | NW. | 18 08 00 | 9.49308 | 9.97788 | 4.65223 | 42668 | 4.63011 | 13974 | 4.14531 |
| Smithers to Capshaw. | NW. | 89 05 33 | 9.99995 | 8.19971 | 4.04765 | 176.7 | 2.24736 | 11158 | 4.04760 |
| Athens church. | SW. | 87 30 25 | 9.99959 | 8.63847 | 4.51249 | 1415.7 | 3.15096 | 32515 | 4.51208 |
| Penit. | SW. | 57 41 39 | 9.92896 | 9.72790 | 4.89465 | 41932 | 4.62255 | 66315 | 4.82161 |
| Tanyard. | SW. | 75 49 30 | 9.98657 | 9.38896 | 4.86082 | 17774 | 4.24978 | 70370 | 4.84739 |

Combining the above results, we obtain the following table of the number of meters that each point is north, south, or west of Rowe:

| Stations. | N. | S. | E. | W. |
|---|---|---|---|---|
| | *Meters.* | *Meters.* | | *Meters.* |
| Rowe. | 0 | 0 | | 0 |
| Smithers. | 30725.0 | | | 8432.0 |
| Capshaw. | 30902.0 | | | 19590.5 |
| Wilson. | | 13359.0 | | 26973.0 |
| Penit. | | 11207.0 | | 74747.0 |
| Tanyard. | 12951.0 | | | 78802.0 |
| Trinity Flag. | 7074.0 | | | 53198.0 |
| Madkin. | 14175.0 | | | 10969.0 |




UNITED STATES COAST AND GEODETIC SURVEY.

Sketch showing Reconnaissance for extension of Primary Triangulation in Northern Alabama.

Scale = $\frac{1}{600.000}$

These positions when projected in their appropriate squares, as in the sketch, show that Tanyard must see Wilson in order to complete the scheme of triangulation up to the side Tanyard-Penit. This line crosses Trinity Ridge about 4 miles SSW. from Trinity flag-tree, which is near the northern end of the ridge. The whole ridge is heavily wooded and broad, and cannot be seen over from the ground at either Wilson or Tanyard. From the table we obtain directions and distances from Tanyard to Wilson and Rowe:

| | | |
|---|---|---|
| Tanyard N. | 12951 W. 78802 | |
| Wilson S. | 13359 W. 26973 | |
| Tanyard north of Wilson = 26310 W. 51829 | | = 4.71457 |
| | | = 4.42012 |
| Wilson to Tanyard NW. 63° 05′ 10″ | | tang = 0.29445 |
| | | sin = 9.95021 |
| Distance Wilson to Tanyard = 58125 meters or 36.12 miles. | | = 4.76436 |

| | | |
|---|---|---|
| Tanyard | = N. 12951 W. 78802 | |
| Rowe | = 0 0 | |
| Tanyard north of Rowe = | 12951 W. 78802 | = 4.89654 |
| | | = 4.11230 |
| Rowe to Tanyard NW. 80° 40′ 00″ | | tang = 0.78424 |
| | | 9.99421 |
| Distance to Rowe to Tanyard or 49.62 miles. | = 79860 meters | = 4.90233 |

It will be noticed upon the sketch that the line most needed (Tanyard-Wilson) intersects the line Smithers-Penit very close to the top of Trinity Ridge. Calling the point of intersection $x$, we get approximate distances by computing the two triangles—

| | | | |
|---|---|---|---|
| Smithers-Wilson | | | = 4.67965 |
| $x$ | = 59° 11′ (concluded) | co-ar sin | = 0.06610 |
| Smithers | = 34° 53′ | sin | 9.75733 |
| Wilson | = 85° 56′ | sin | 9.99756 |
| **Wilson — $x$ = 31848 meters.** | | | **= 4.50308** |
| **Smithers — $x$ = 55375 meters.** | | | **= 4.74331** |

| | | | |
|---|---|---|---|
| Smithers-Tanyard | | | = 4.86082 |
| $x$ | = 120° 49′ | co-ar sin | = 0.06610 |
| Smithers | 18° 08′ | | 9.49308 |
| Tanyard | 41° 03′ | | 9.81738 |
| **Tanyard — $x$ = 26303** | | | **= 4.42000** |
| **Smithers — $x$ = 55501** | | | **= 4.74430** |

The approximate heights above sea are—

Rowe = 1402 feet, and at Smithers the approximate zenith distance of tops of trees at $x = 90° 24' 56''$, which gives approximate elevations of tops of trees at $x = 870$ feet.

Wilson = 1185 feet.

Smithers = 1490 feet, Telescope at Wilson = 70 feet above station point, or 1255 feet above sea.

Tanyard = 850 feet, Heliotrope at Wilson, 85 feet above station point, or 1270 feet above sea.
Telescope at Tanyard, 101 feet above station point, or 951 feet above sea.
Heliotrope at Tanyard, 106 feet above station point, or 956 feet above sea.

A reduction of these quantities shows that the line Wilson-Tanyard will pass about 40 feet above the trees upon the intervening ridge, as represented by the point $x$, and the line is practicable at the elevations named.

Approximate computations and tables like those here given are of very great service where long lines are sought for, in insuring certainty of pointing the telescope in thick and hazy weather. As has been before stated, approximations to within 100 to 150 meters will suffice to insure that the point looked for is within the field of view, and much tedious "sweeping" and possible doubt as to the point looked for being visible will be avoided.

Of course in the level plains and prairies, and the densely wooded swamps of the West and South, no such methods of even approximate precision are possible, and only a careful examination of every part of every line will render intervisibility certain. Close examination of the best local maps obtainable will always show where the various and diverging water-courses head, and the highest ground will, as a rule, be found in that vicinity, and will help to narrow the field of personal research.

In all the different forms in which primary triangulation is to be laid out, and whatever may be the ground to be covered, the observer needs to set before himself clearly the points to be aimed at, the principles to be applied, and the methods to be pursued. A quick eye and ready perception, with a habit, natural or acquired, of self-orientation—by which I mean the faculty of knowing at any point visited for the first time just where to look for other points requisite to the work in hand—will best help to securing a full knowledge of the country, and will suggest the best methods of laying out the work.

Very full notes and sketches should accompany every journal of reconnaissance. Every point which may aid a successor should be carefully noted and recorded. Among these some of the most important are the means of access; condition of roads or paths to be traveled; what tracks must be opened in the final occupation of the station; the estimated cost in time, labor, and money of occupying the station; probable amount of damages to be paid, if any; names of the persons living near the station, and a sketch showing their residences; the name and residence of the owner, and whether his views as to the use of his land are favorable or otherwise; the nearest post-office, and place from whence supplies may be procured; whether the party occupying the station may be boarded near it, or if an encampment will be requisite; and (if a heliotrope or night-signal, or both, are likely to be needed) where a proper man for the work may be found. Indeed it is impossible to be too minute in descriptions of the selected stations.

The best instruments are a gradienter, with level, micrometer, and magnetic needle. This small and compendious instrument comprises in itself every essential requisite for a reconnaissance where observations may be made upon the ground, and the sides do not exceed 25 miles in length. For longer sides it will be best to add a reconnoitering telescope and stand. A tape-line 100 feet long, of the kind which has wires woven into the marked linen, is also needed.

For reconnaissance in a wooded country, where observations must be from tree tops, a small 6-inch sextant, with telescope attached, of the form now most used in hydrography, will be better than the usual pocket sextant. This and a good spy-glass and a prismatic compass are all the instruments needed. A set of spurs, like those used by telegraph linemen, will be found useful, as will also a coil of manila rope, about 100 feet long, and strong enough to bear the weight of a man, with a ball of marline, and another of strong twine, and a supply of different colored material for flags. A horse and covered wagon, with one active, intelligent man, of the class who can "turn their hands to anything," and who are not afraid to go aloft, will complete the outfit requisite for a reconnoitering party.

SELECTION OF STATIONS FOR SECONDARY AND TERTIARY TRIANGULATIONS.

Reconnaissance for selection of stations to be occupied as secondary triangulation points involves a search of a very different nature from that we have been considering. While primary triangulation covers the country with the fewest possible number of triangles, each having the largest possible area, the object of the secondary work is to multiply stations for the use of the topographer and hydrographer.

As these stations abut upon and are connected with the primary stations, and any error introduced will not be multiplied and extended, the same elaborate methods of observation are not necessary. The length of triangle sides rarely exceeds 25 kilometers, and the average length is not more than 10 kilometers.

The reconnaissance for a secondary triangulation becomes, therefore—

(1) A selection of points of the first order which shall start from long primary bases, and shorten the sides of the triangles while commanding the country to be surveyed in detail by the topographer and hydrographer. These points should be all occupied, and the triangles should close with average errors not exceeding one to two seconds to an angle.

(2) Secondary triangulation points of the second order, based upon the primary and first order points, and so located as to command every prominent object visible, or which may be rendered visible for observation from two or more stations. Sufficient precision will be attained if the second order triangles close within three seconds to an angle.

(3) Tertiary triangulation points, to be observed upon and not occupied. These should include every prominent point, such as church spires, cupolas, chimneys, flags in prominent trees, indeed everything which will multiply useful data for the topographer to have correctly plotted on his plane-table sheet, or the hydrographer to "angle" upon in determining the position of his boat while sounding. Of these points there cannot be too many, and in a difficult country, as upon portions of the bold and rocky shores upon the Maine coast, or upon the Pacific, every device possible to multiply these "tertiary points" should be tried. Large white crosses and triangles painted upon rocky bluffs make very useful points. Flags in prominent trees also. In the case of using trees they may be marked for future reference by cutting large triangles through the bark and into the wood upon the tree at its base.

The officer charged with this work should specially bear in mind that his duty does not consist in laying out well-shaped and symmetrical series of triangles. The form of each secondary triangle is of comparatively little consequence, except where it forms part of a system for extending a work over a region where no primary triangulation is carried, as upon parts of the Florida coast. In all other places symmetry of form should be made to give place to the multiplication of tertiary points from well-selected secondary ones.

Where possible *three* lines from secondary stations should be made to converge upon each tertiary point, in order to check errors of observation which may possibly creep in, and which could not be detected where there is only a single triangle.

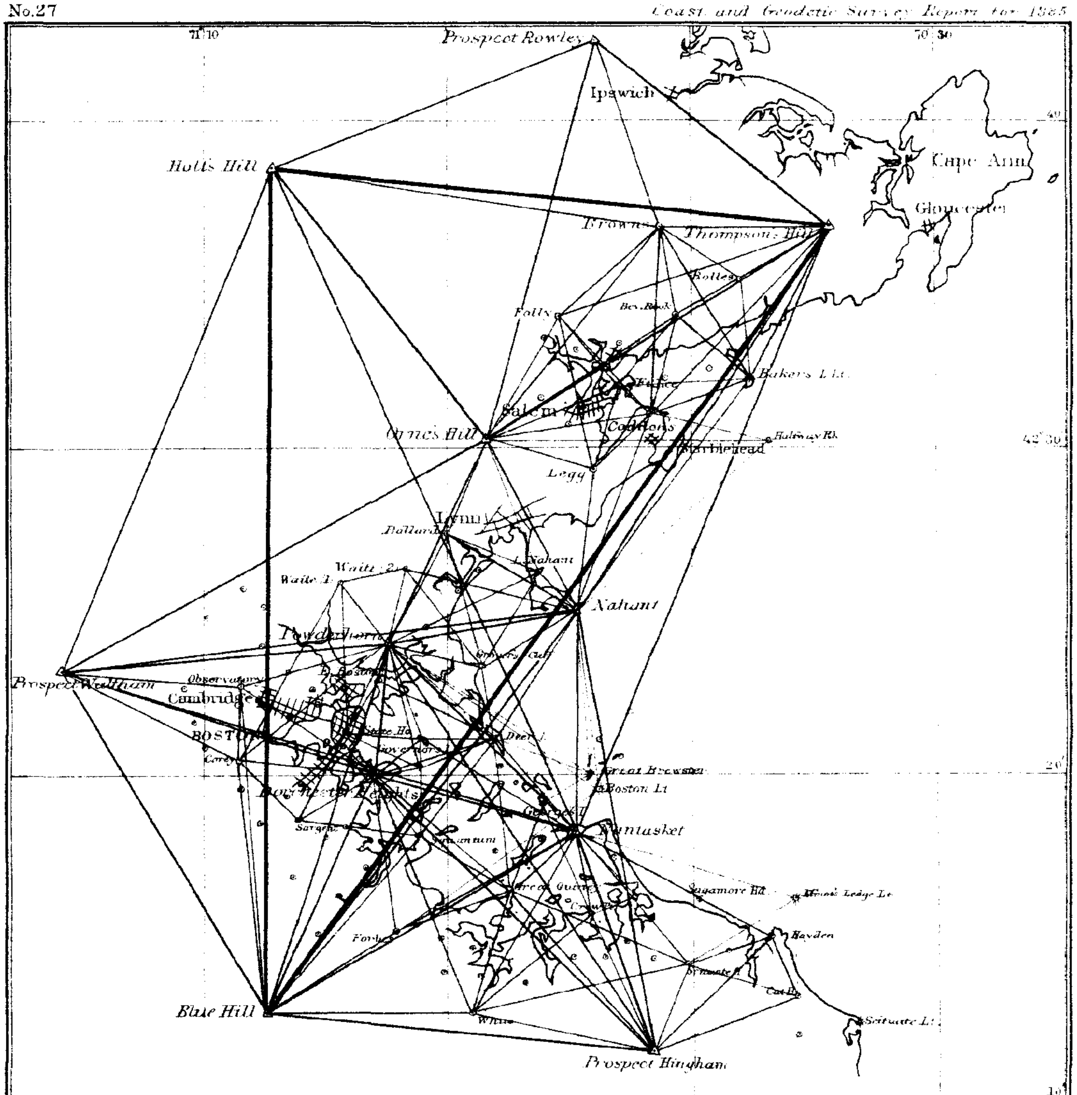
Single readings, direct and reversed, are sufficient in observing upon tertiary points where the instrument used reads to 10 seconds.

Very careful descriptions should be made in the note-book of both reconnoitering officer and observer of all tertiary points observed upon. This is of great importance where the triangulation is largely in advance of the other parties. But it is also necessary in view of future surveys in future years. Prominent tertiary points observed in the Massachusetts Trigonometrical Survey, made between 1834 and 1840, are being identified and used in the resurvey of that State now in progress.

The sketches Nos. 27 and 28, which follow, illustrate all the above varieties of secondary triangulation. In the first, upon the coast of Massachusetts, the country is hilly and comparatively open, and large numbers of tertiary points are easily determined.

In the second, upon the coast of South Carolina, no natural elevations of 20 feet can be found, while forest trees abound and points for the topographer and hydrographer are had with difficulty.* But, as a rule, there is a triangulation point for every square mile.

* Attention is called to the use of the wide avenues opened upon the primary lines in furnishing secondary bases.




U. S. Coast and Geodetic Survey

Sketch showing

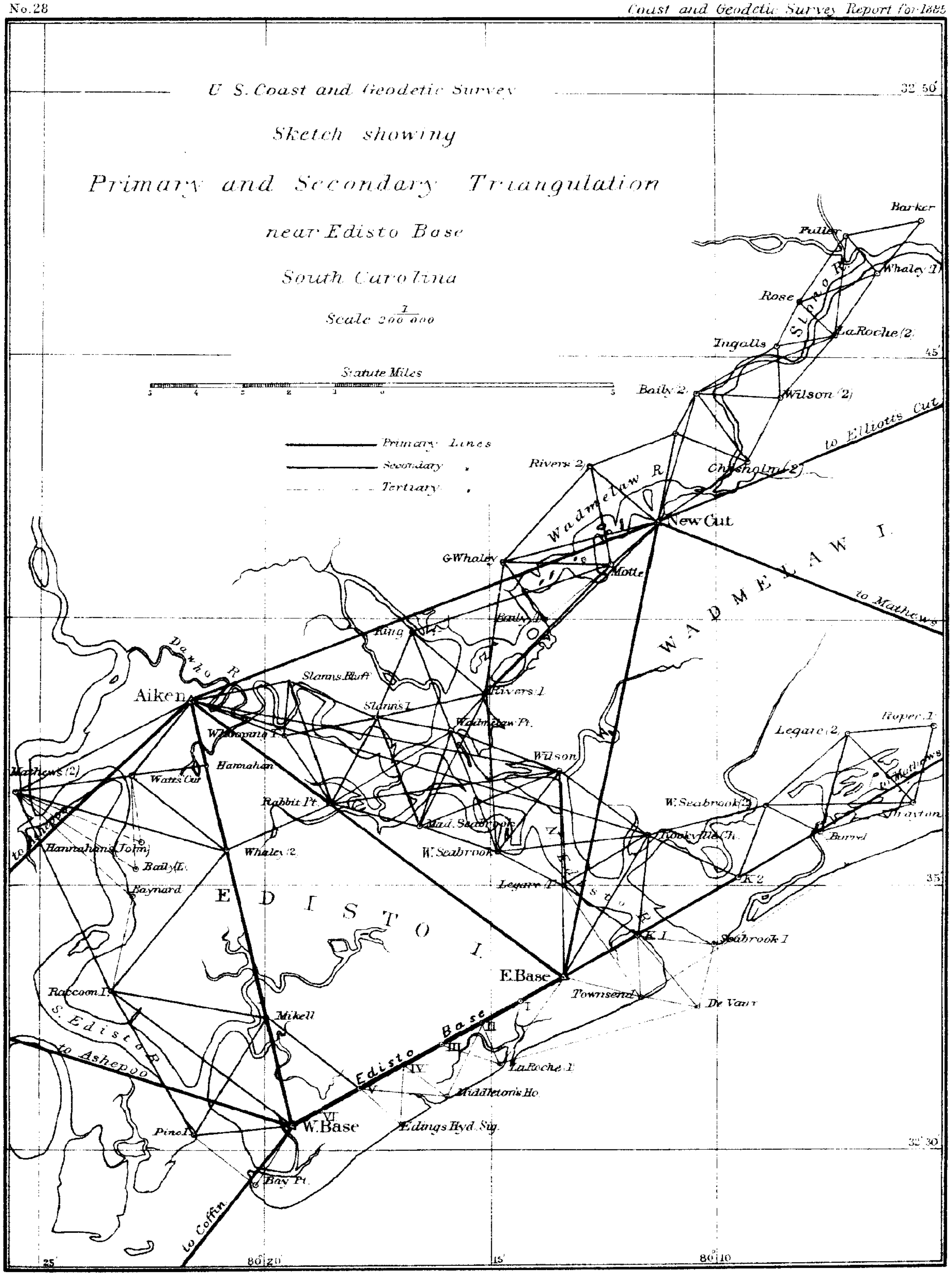
# Secondary Triangulation of Boston Bay

Scale $\frac{1}{400\,000}$

Sides of Primary Triangles
" Secondary " of First Order
" " " of Second "
" " " of Third "

Triangle sides to Tertiary Points and their names are omitted that sketch may not appear complex.

Statute Miles
5 4 3 2 1 0 5 10 15 20


U. S. Coast and Geodetic Survey
Sketch showing
Primary and Secondary Triangulation
near Edisto Base
South Carolina
Scale 1/200 000
Statute Miles
Primary Lines
Secondary "
Tertiary "
Wadmelaw R.
Wadmelaw I.
Edisto I.
Edisto Base
S. Edisto R.
Dawho R.
to Elliotts Cut
to Mathews
to Ashepoo
to Coffin
Aiken
New Cut
E. Base
W. Base
Mikell
Raccoon I.
Pine I.
Bay Pt.
Edings Hyd. Sig.
Middleton's Ho.
LaRoche 1
Townsend
De Vaux
Seabrook 1
K 1
K 2
Legare 1
W. Seabrook
W. Seabrook (2)
Rockville Ch.
Burnel
Legare (2)
Roper 1
Wilson
Wadmelaw Pt.
Rivers 1
Rivers 2
Stanns 1
Stanns Bluff
King
Baily 1
Motte
G. Whaley
Chisholm (2)
Baily 2
Wilson (2)
Ingalls
LaRoche (2)
Rose
Whaley (1)
Fuller
Barker
Rabbit Pt.
Mad. Seabrook
Whaley 2
Hamahan
Watts Cut
Mathews (2)
Hannahans John
Baily (L.
Baynard
32° 50'
45'
35'
32° 30'
25'
80° 20'
15'
80° 10'

In this memoir I have avoided theoretical discussions and only set forth practical details. For full discussion of the geometrical and mathematical principles involved, I refer to Assistant Schott's Appendix 20, Report of 1876, on the "Adaptation of Triangulation to the various conditions of configuration and character of the surface of the country, and other causes." Also to "Clarke's Geodesy," vol. 1, 8vo., Oxford, 1880; and to "Jordan's Geodesy," vol. 2, 8vo., Stuttgart, 1877; and "Principal Geodetic Points, and their Co-ordinates," vol. 1, 8vo., Berlin. The two last-named works are in German.

In conclusion, the writer desires to say that he has embodied in this paper an experience of over forty years, covering every department of Coast and Geodetic work. If he has succeeded in bringing together information useful to his comrades and successors, he will have accomplished the end sought for and will be amply repaid.

C. O. BOUTELLE,
*Assistant.*

The SUPERINTENDENT
U. S. COAST AND GEODETIC SURVEY.

# APPENDIX No. 11.

## A PLEA FOR A LIGHT ON SAINT GEORGE'S BANK.

By HENRY MITCHELL, Assistant.

To our late Superintendent, Prof. J. E. Hilgard, as a member of the Light-House Board, I made a communication some months since concerning the necessity of lights upon the summit of Saint George's Bank. Perhaps in all my experience as a coast surveyor I have never felt that I was doing more Christian service than when compiling the notes that I beg leave to repeat below.

Although the position of Cape Sable was accurately determined in 1755, the whereabouts of the George's was still a mystery at the beginning of this century. Dr. Franklin had declared its latitude, and his conclusion was correct, but he did not venture to mention its longitude, and the charts that adopted his latitude put the shoals 35 miles out in longitude. One has but to glance at the chart to guess how much mischief such an error of position must have caused. The charts of that time did not agree, happily, so that the navigator did not trust them, as he now does, implicitly. But as the charts improve, the day and night marks of shoals become not less but more essential. The navigator has now a chart that he knows is correct, and he lays down his course with the slightest possible deflection from a straight line, and as he shaves the dangerous reef or shoal he expects to find a warning mark, for there is time and property and life to be saved, and the whole community shares the risk and the danger. Should it not be a surprise then to us that the greatest danger on our coast, and the one feared by the largest number, perhaps, of seamen, is unmarked and undistinguishable except by its hideous roar when the ship is already within its breakers?

Saint George's Bank lies at the threshold of the Gulf of Maine, and its summit is called distinctively "George's Shoal," or "The Georges." Twenty miles westward of the Georges is the "Cultivator Shoal." Upon the Georges there are two spots of 12 feet given by chart, while upon Cultivator Shoal there is not less than 18 feet. (See Annual Report Coast and Geodetic Survey, 1879, Appendix No. 10, for physical conditions.)

If we draw a line from the Nantucket South Shoal light-ship to Brazil Rock, off Cape Sable, we find Cultivator Shoal 12 nautical miles outside (seaward) of this line, and the 12-foot limit of the George's 22 miles outside of the same line. These shoals then are outside of the Gulf of Maine and beyond the general trend of the coast.

Again, if we draw a line from Hatteras to Cape Sable, which passes 150 miles seaward of Sandy Hook (at the apex of the great bay, of which our line is the chord), we still find George's Shoal a salient protruding into the ocean.

It is 100 miles from the nearest land, Chatham, Cape Cod. Its situation relative to the continent is like that of Sable Island, and, like this island, it would long ago have been lighted if *dry land*. As a shoal it is far more dangerous than it would be as an island, and therefore it is shunned and feared except by fishermen who are obliged to brave its dangers.

If we draw a line from Nantucket light-ship to Cape Race (Newfoundland), it passes about 6½ miles outside (southward) of the Cultivator Shoal, but it passes directly over George's Shoal between the 18 and 24 foot contours, where the lightest draught vessel can rarely pass in safety because of breakers. Thus we see that *George's Shoal, an unmarked danger, lies in the shortest water route between New York and Liverpool* (and other ports of Northern Europe), and the fear of it makes voyages longer and more anxious. But for this, vessels that now go wide out to sea, making a great detour, would run coastwise within Sable Island, which is well lighted. As it is, unless Halifax or some other port of Nova Scotia is to be visited, vessels run far southward. Still, even under present conditions, vessels from Europe haul in to make Nantucket light-ship, and if they do so skilfully they pass within 10 miles of the 12-foot spot on George's Shoal.

A line from Nantucket light-ship to Sable Island eastern light passes 10 or 11 miles outside of the Cultivator Shoal and 4 or 5 miles outside of George's. Now, parallel to this line at a safe sighting distance from Nantucket Shoals and Sable Island lights, a ship's course would still be only 10 miles off George's—*near enough to see an ordinary light-ship*, if our Government could not afford a more generous spark.

It is not alone the direct danger from this *lion in the path* that we would present as a reason for a warning light, but the advantage also of the light itself as a guide. With this warning and guiding light the European commerce of New York would gain time and reduce its risks; and in less measure, but still to an important degree, the ocean commerce of Boston, Salem, Newburyport, Portsmouth, Portland, Bath, Bangor, Saint John, &c., would be benefited.

In our remarks, thus far, we have not considered the fishing fleet.

One easily sees that the shortening of time, however slight, and the diminution of risks however small, as affecting the grand ocean commerce, must command attention. But it is not so obvious that small fishing vessels that seek these shallow waters can receive benefits from a local light to any extent deserving consideration, especially as their fishing ground covers 500 square miles of "George's Bank."

It must be remembered, however, that the fishing fleet of the Gulf of Maine numbers over 600 sea-going vessels of 30 to 300 tons each, with average, perhaps, 70 tons. Of these there may be at times 400 fishing on the George's or crossing the shoals *en route* to more distant grounds. These 400 vessels carry about 4,000 men, all working on shares, and presenting the most just and most useful form of co-operative industry that our country offers. The vessels seeking Provincetown Harbor, the nearest good shelter, sometimes number 500 by actual count.

We may conceive of the Georges fleet (of 100 vessels perhaps) as gathering in towards the summit of the Bank, as near as would be safe, without very definite boundaries or uniform distribution of vessels. The light that we propose, and the powerful horn placed at the nucleus of this fleet, would reach a very considerable part of the vessels and serve to *maintain their reckoning*. In the present state of things not only do skippers form a very indefinite idea of the whereabouts of the shoals when fresh from port, but after a few days' cruising they not unfrequently lose their reckoning altogether. We submit that the sight of a light on George's Shoal, or the sound of a horn from that much dreaded spot, would enable many a fishing vessel to stand away for port, when the storm threatens, instead of attempting to ride out the gale at anchor or lie-to with fear of dragging upon the shoal or fouling with another of the fleet. "Though none of our fisheries are exempt from peril, it may safely be said that the winter cod fisheries on George's Bank and the trawl fishery, especially that for haddock and halibut in winter, are the most dangerous of all." These words we quote from the "Fisherman's Own Book," and from this book, and other sources, we learn that in 1879 Gloucester alone lost 13 vessels and 143 lives; in 1882, 4 vessels with 51 lives, and in 1883–'84 18 vessels and about 180 lives. I give the figures for a few years only and only for the Gloucester fleet, which covers but two-thirds of the interest of fisheries on the Georges, perhaps.

It is impossible to say what proportion of these vessels might have run into port, had they known their exact whereabouts, or how many times, for fear of being caught thus in a dangerous neighborhood, the fleet has unnecessarily left the fishing ground. One need not speculate upon the economical relations of the case, the story is bad enough as it stands!

Here we have a breaking shoal lying exactly on the shortest route from New York to the British Channel, and near the routes of all the ocean commerce of Massachusetts Bay and the Bay of Fundy, with no warning light! Moreover, it is the resort of a great fleet of winter fishing vessels that lose their reckoning, and thus their chance of making a safe harbor in the gale, because no signal upon the shoal gives them the correct bearings and distances of the numerous ports which lie around them. They often do not know which direction from them the summit of the shoal lies and are afraid to move from the position which thick weather and darkness finds them in.

Mr. C. H. Farley, chairman of the harbor commission of Portland (writing unofficially, it should be said), mentions that "the Dart was the largest privateer of the war of 1812. She sailed from this port and was lost on George's. The brother of the captain was a prominent merchant of Portland, and ever after that disaster, as long as he lived, advocated the building of a monument on that shoal. The bones of all who have perished there would make a monument higher than that on Bunker Hill; and the property lost would pay for one of silver, if not too high."

My proposition, less equivocal than that of the privateersman's brother, is, that to our brothers, the fishermen and peaceful traders who have died for us on George's Shoal, let us raise a monument in the form of a light-house and furnish it with a fog-horn to utter one perpetual wail.

HENRY MITCHELL,
*Coast and Geodetic Survey.*

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# APPENDIX No. 12.

## COMPARISON OF TRANSVERSE SECTIONS IN THE DELAWARE RIVER, BETWEEN OLD NAVY-YARD AND EAST END OF PETTY'S ISLAND, FOR THE YEARS 1819, 1843, AND 1878.

By HENRY L. MARINDIN, Assistant.

UNITED STATES COAST AND GEODETIC SURVEY,
*Boston, Mass., March* 30, 1885.

DEAR SIR: I have prepared and desire to submit herewith a report on Transverse Sections in the Delaware River, between Old Navy-Yard and East End of Petty's Island, compared for the years 1819, 1843, and 1878.

The following comparison of the changes in the transverse section of this part of the Delaware River was undertaken because it embraces the principal part of the harbor of Philadelphia, and although comparisons have been made before by giving the shift of the river bed by volumes, no showing has been made by means of profile of cross-section. The importance of this part of the river may be inferred from the fact that it covers both of the Windmill Island channels, also Smith's Island Bar, and both of the channels around Petty's Island. The selection of the transverse sections was determined by the position of the sounding lines of the survey made by McClure in 1819. These sounding lines were run, in most cases, so as to give a fair cross-section of the stream, although not at equal distances apart.

The changes are represented on the accompanying six plates, which explain themselves in a great measure. Some of the notable changes I will call your attention to briefly.

From Section 1, off Old Navy-Yard, to the present southern extremity of Windmill Island, the cross-sections reaffirm the discovery, in a preceding comparison of depths, of the increase of depth on the shoal ground south of Windmill Island. The wharf line indicates a general advance into the stream, with a corresponding deepening in the channel and an easterly movement of the westerly slope of the shoal, with an exception at Section 3, where this slope has remained stationary for the three epochs. Here at Section 3, off Pier 36, it would seem that the compensation for the advance of the wharf line was obtained wholly by the disappearance of the apron shown as existing in 1819 on the city front (see Section 3). Another feature of this cross-section is the disappearance of the dry-ground end of Windmill Island, already alluded to in another report.

From cross-section 4 to 9 we have the comparison of both of the Windmill Island channels. We may continue to notice the advance of the wharf-line, more marked however, between the years 1843 and 1878. This advance has in most cases been followed by an increase of channel depth, which is an improvement only where the depth is insufficient; but here the depth exceeds the wants of commerce, so that a questionable improvement was obtained at the expense of width of water-way where navigable room was already restricted. The depth along the island front has remained without change.

In the eastern channel the marked advance of the Jersey shore, by its occupation by wharves, has also been followed by increase of channel depth.

From Section 9 to 12 we have cross-sections over Smith's Island Bar. The advance of the wharves on the Philadelphia front is still maintained. A great importance attaches to this part of the harbor from the fact brought out by the resurvey made by the United States Engineer Department, under Colonel Ludlow, in 1882, that the bar was shifting towards the Philadelphia shore at an alarming rate, in one case 300 feet since the survey of 1878. While this is true of the *crest of the bar* off the foot of Callowhill street (shown in cross-section 12), which was, I believe, the point indicated by the resurvey, the examination of cross-sections 11, 10, and 9 would indicate the opposite tendency, that of a retreat of the western slope of the Bar towards the Jersey shore. The width of channel-way between the Bar and the Philadelphia shore remains the same, as the shift of the Bar was either followed or preceded by the advance of the wharves in the same direction.

At Section 9, off the foot of Market street, and at Section 10, off the foot of Arch street, the increase of channel depth following the advance of the wharf line is not so decided as was the case along the frontage south of Market street; the easterly shift of the western slope of the Smith's Island Bar is probably the effect of the advance of the wharf line along the city front. The inference to be drawn from the inspection of the changes shown in the transverse sections 9 to 12 might be that Smith's Island Bar is shifting, but more especially above Arch street, from there to the Elbow at Cooper's Point.

Cross-sections 13, 14, and 15 show the changes at the Elbow at Cooper's Point. The encroachment on the channel by the building out of the wharves is still apparent, but the large sectional area in this bend was not affected to such a degree as the part of the stream below this point.

The remaining cross-sections from No. 16 to 21 give the changes in the north channel of Petty's Island, and those from No. 22 to 29 show the same for the south channel along the Jersey shore. I had intended to deduce from these sections the comparative value of the two channels for the different dates of the surveys, but will have to postpone this inquiry to a future occasion for want of time.

Trusting that these plats may be of use in the future study of the changes and projected improvements for this part of the Delaware, I respectfully submit them.

Very respectfully,

HENRY L. MARINDIN,
*Assistant Coast and Geodetic Survey.*

Prof. J. E. HILGARD,
*Superintendent Coast and Geodetic Survey.*

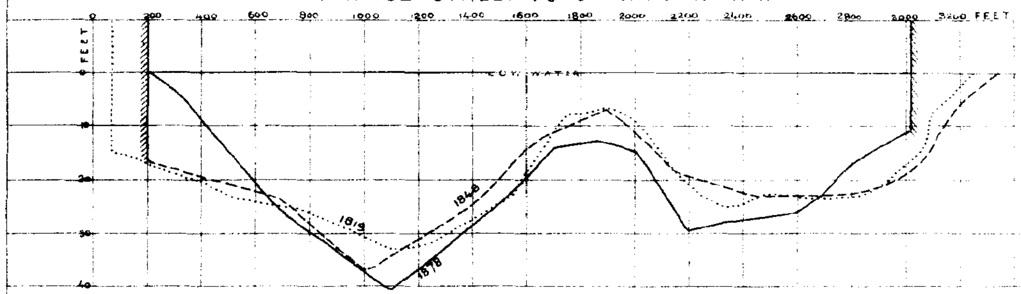
# DELAWARE RIVER

## TRANSVERSE SECTIONS COMPARED FOR THE YEARS

## 1819-1843-1878

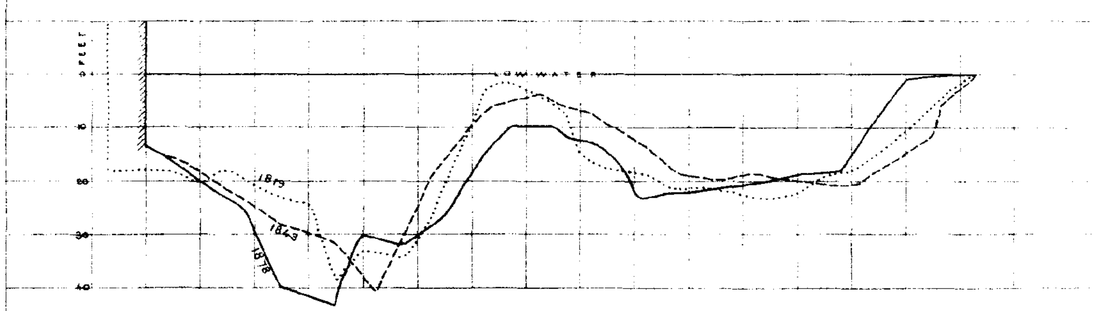
### SEC. 1

### PRINCE STREET TO STARR'S WHARF




### SEC. 2

### SIMPSON'S DRY DOCK TO AM. DREDGING CO$^S$ LANDS



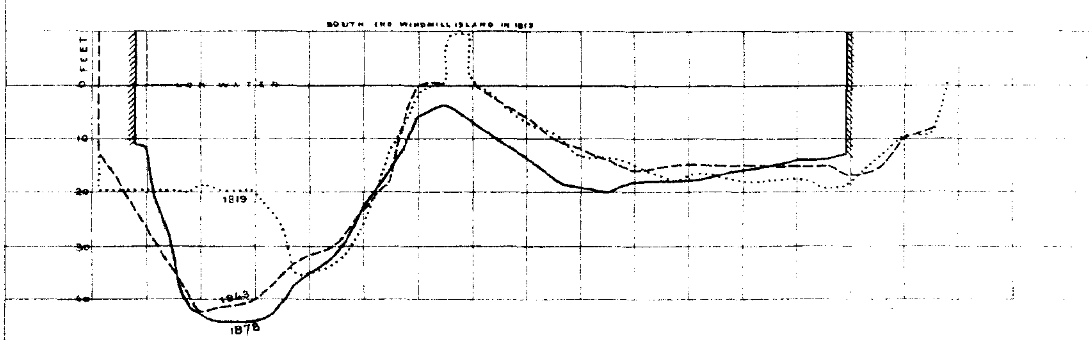

### SEC. 3

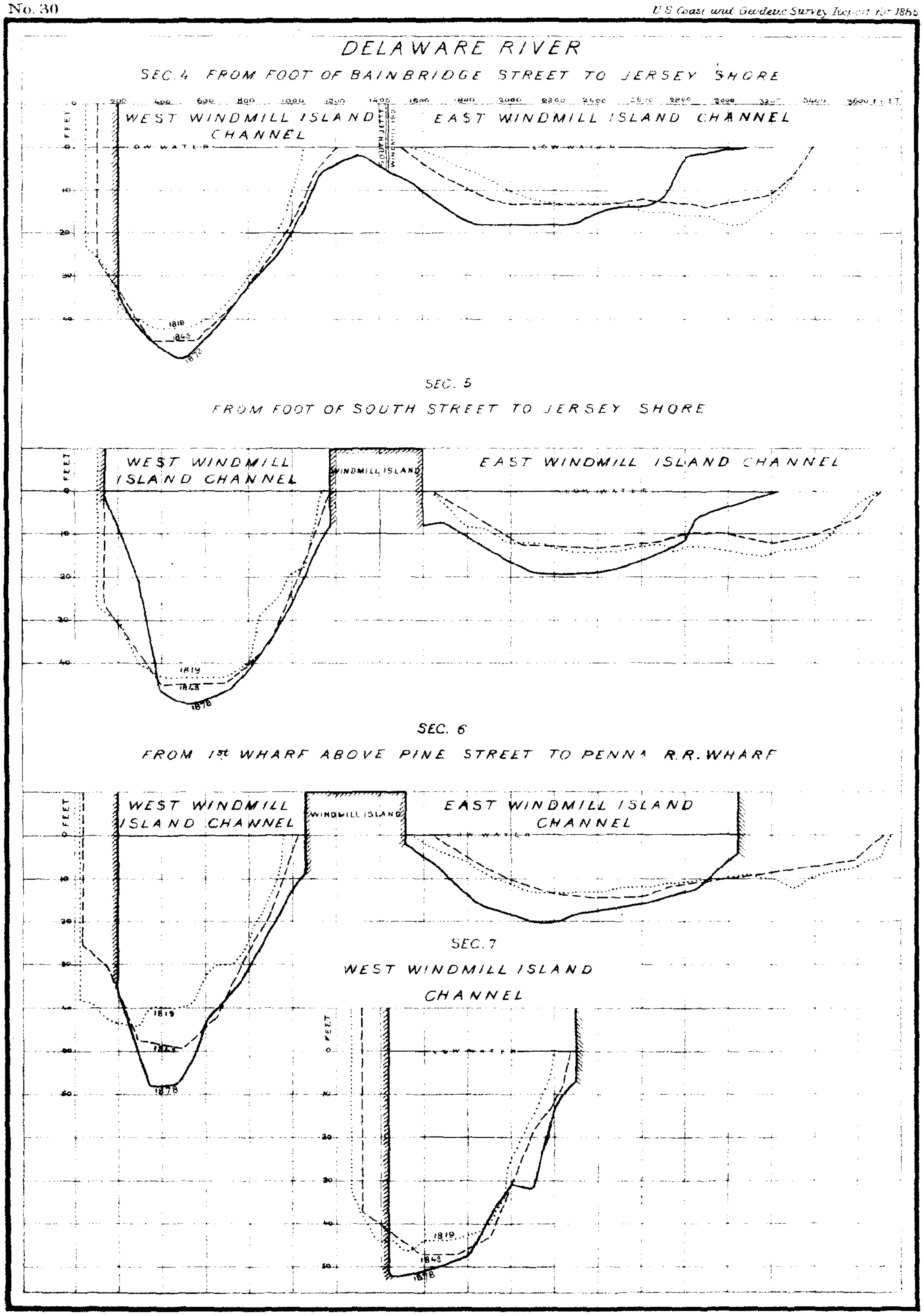
### WEST WINDMILL ISLAND CHANNEL

### PIER 36 TO AM. DREDGING CO$^S$ LANDS

### SEC. 3

### EAST WINDMILL ISLAND CHANNEL

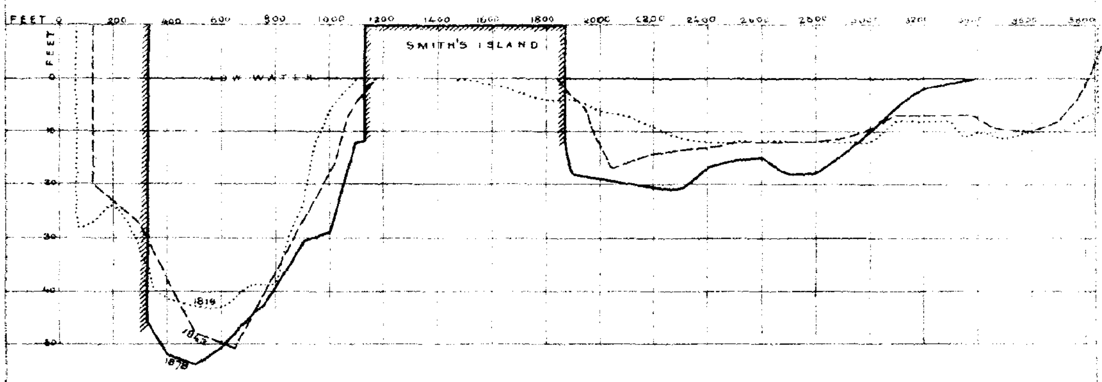



DELAWARE RIVER
SEC. 4 FROM FOOT OF BAINBRIDGE STREET TO JERSEY SHORE
WEST WINDMILL ISLAND CHANNEL
EAST WINDMILL ISLAND CHANNEL
LOW WATER
FEET
1819
1843
1878
SEC. 5
FROM FOOT OF SOUTH STREET TO JERSEY SHORE
WEST WINDMILL ISLAND CHANNEL
WINDMILL ISLAND
EAST WINDMILL ISLAND CHANNEL
SEC. 6
FROM 1st WHARF ABOVE PINE STREET TO PENNA R.R. WHARF
WEST WINDMILL ISLAND CHANNEL
WINDMILL ISLAND
EAST WINDMILL ISLAND CHANNEL
SEC. 7
WEST WINDMILL ISLAND CHANNEL

# DELAWARE RIVER

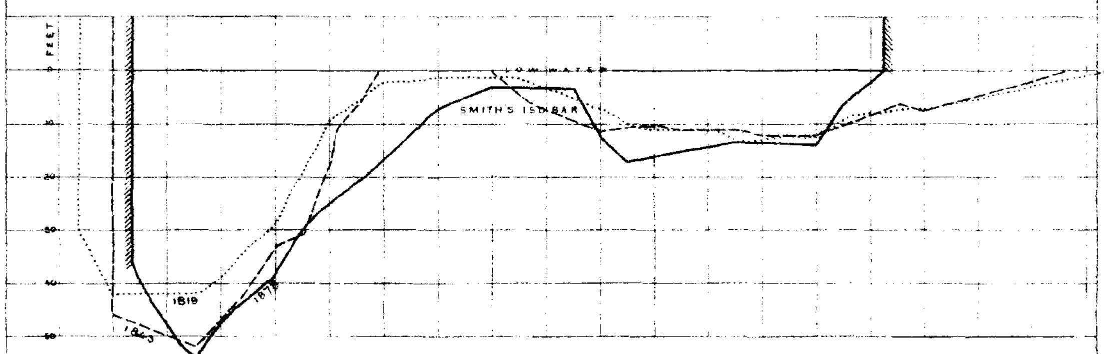
SEC. 8

WALNUT STREET WHARF TO ARCH STREET, CAMDEN



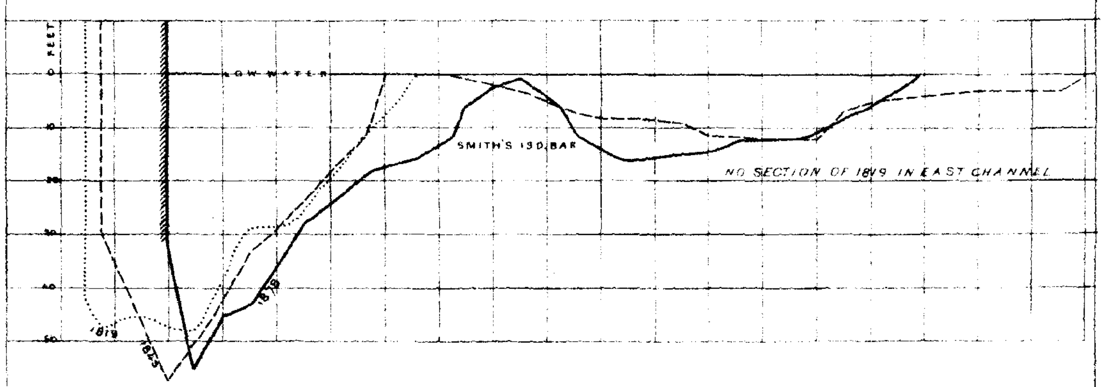

SEC. 9

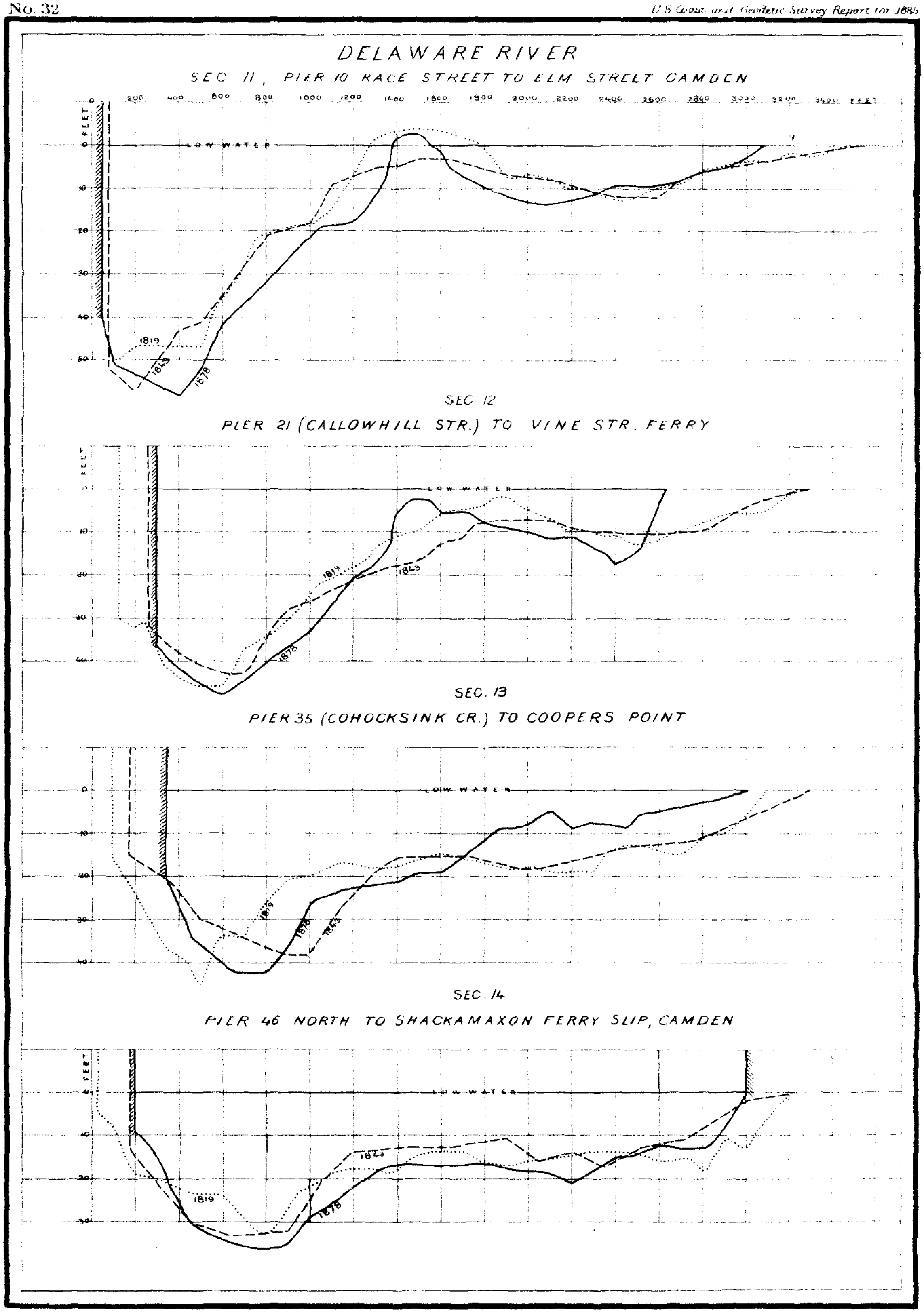
FOOT OF MARKET STREET TO KNICKERBOCKER ICE CO'S WHARF

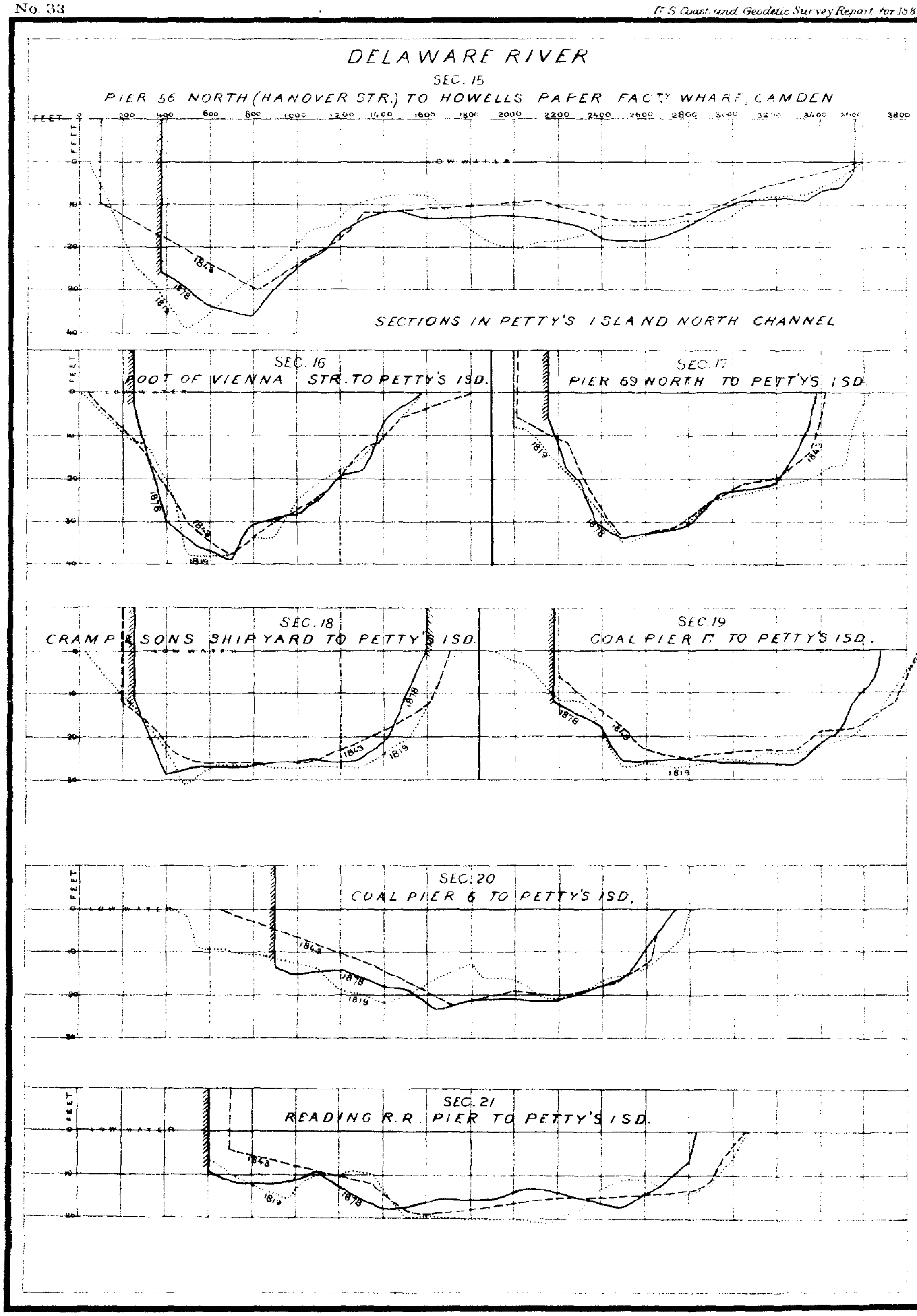



SEC. 10

ARCH STREET WHARF TO JERSEY SHORE

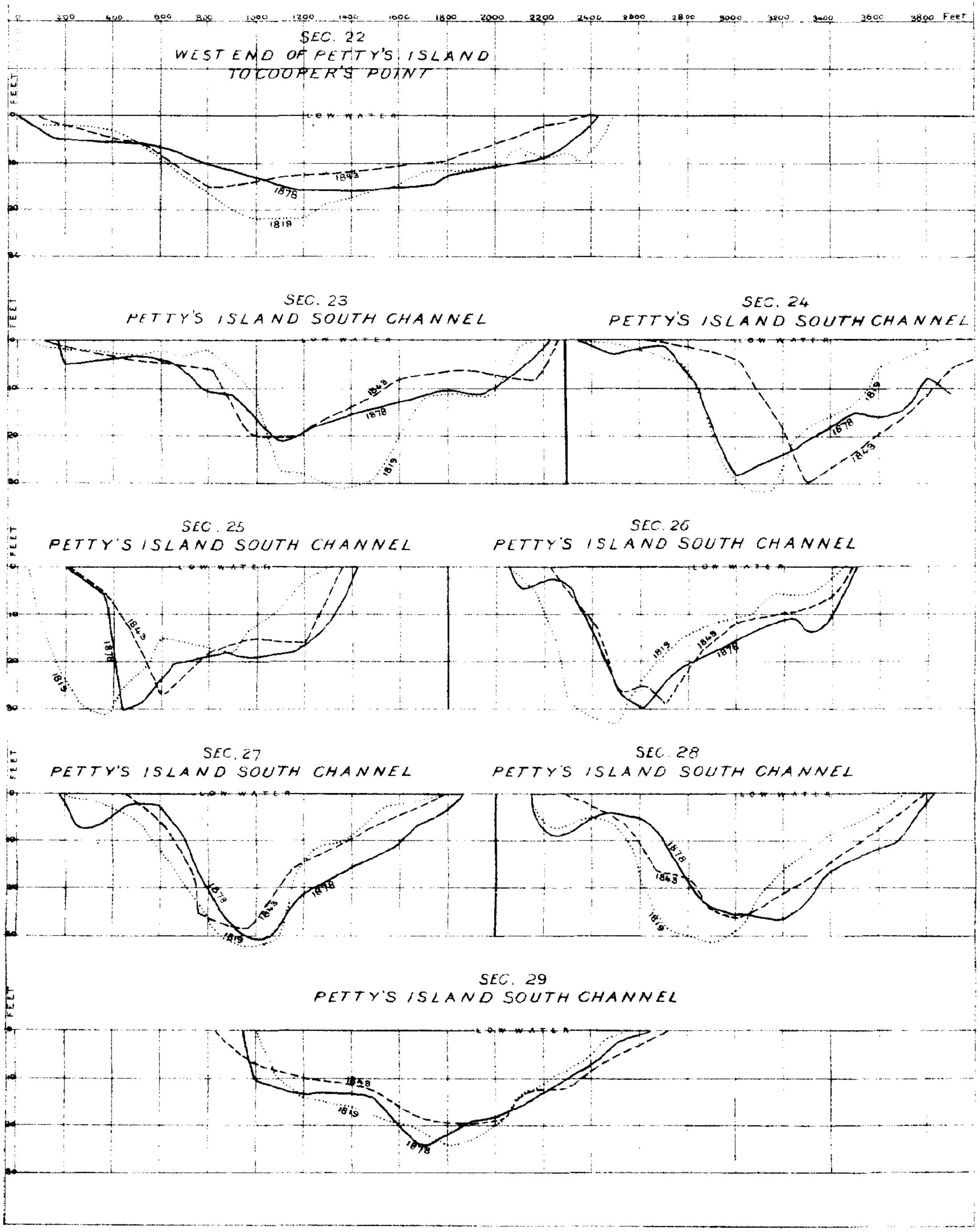



DELAWARE RIVER
SEC. 11, PIER 10 RACE STREET TO ELM STREET CAMDEN
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000 3200 3400 FEET
FEET
LOW WATER
0
10
20
30
40
50
1819
1843
1878
SEC. 12
PIER 21 (CALLOWHILL STR.) TO VINE STR. FERRY
FEET
LOW WATER
1819
1843
1878
SEC. 13
PIER 35 (COHOCKSINK CR.) TO COOPERS POINT
LOW WATER
1819
1878
1843
SEC. 14
PIER 46 NORTH TO SHACKAMAXON FERRY SLIP, CAMDEN
FEET
LOW WATER
1843
1819
1878


DELAWARE RIVER
SEC. 15
PIER 56 NORTH (HANOVER STR.) TO HOWELLS PAPER FACT'Y WHARF, CAMDEN
SECTIONS IN PETTY'S ISLAND NORTH CHANNEL
SEC. 16
FOOT OF VIENNA STR. TO PETTY'S ISD.
SEC. 17
PIER 69 NORTH TO PETTY'S ISD.
SEC. 18
CRAMP & SONS SHIPYARD TO PETTY'S ISD.
SEC. 19
COAL PIER 17 TO PETTY'S ISD.
SEC. 20
COAL PIER 6 TO PETTY'S ISD.
SEC. 21
READING R.R. PIER TO PETTY'S ISD.

# DELAWARE RIVER

## SECTIONS IN PETTY'S ISLAND SOUTH CHANNEL



# APPENDIX No. 13.

## ON THE HARMONIC ANALYSIS OF THE TIDES AT GOVERNOR'S ISLAND, NEW YORK HARBOR.

By WILLIAM FERREL.

WASHINGTON, D. C., *June* 30, 1884.

SIR: I have the honor to submit the following report on the harmonic analysis of the hourly co-ordinates of the heights of the tides at Governor's Island, in New York Harbor, for the years 1876–1878, inclusive. The situation of the tide-station with regard to the entrance to the harbor and the hydrography of the vicinity can be best understood by a reference to the accompanying sketch (No. 35). The hourly co-ordinates, measured from the curves of the self-registering tide-gauge, were furnished to me by Mr. R. S. Avery, chief of the Tidal Division. The series was nearly perfect, only a few co-ordinates having been supplied by interpolation.

The method of analysis was the same as that followed heretofore, the principles of which were explained, and rules, formulæ, and examples of the various reductions given, in Appendix No. 11 of the Report of the Coast and Geodetic Survey for 1878, in which were discussed the tides of Penobscot Bay. We shall, therefore, present here, for the most part, the results merely of the analysis, since to give the work in detail, with examples of the various reductions, would be in a great measure a repetition of what has already been published.

As the tide-station of Governor's Island is only about 20 miles from that of Sandy Hook, there is not only a very great similarity in the tides of the two stations, but the amplitudes of all the separate components are very nearly the same for both. The epochs, however, at Governor's Island, as was to be expected, are somewhat greater, being such as to cause the tides to be about 29 minutes later than at Sandy Hook. The tides, therefore, do not seem to be much affected by waves coming through Hell-Gate from the tides in the Sound above.

The three years included in this analysis are the same as the first three of the six years embraced in the analysis of the Sandy Hook tides. It is interesting to compare the results at the two stations for each of these three years, and observe how nearly the amplitudes of the several components agree, with the exception of a very small regular and proportionate difference, and also the epochs of these components. To facilitate the comparison of the averages of the amplitudes and epochs of the two analyses, those of Sandy Hook are given here by the side of those of Governor's Island.

### RESULTS OF THE ANALYSIS.

The amplitudes and epochs, as given in the following results of the analysis, have all the reductions applied, so that one year is comparable with another and with the mean of all, and the small differences from year to year are simply such as result from an incomplete elimination, with only one year's observations, of all the abnormal disturbances arising from winds and changes of barometric pressure, and also in some measure from unavoidable imperfections of the observations. It is seen, however, that the differences in the amplitudes from year to year are extremely small, and likewise between each year and the average of all. The epochs also agree very well in all cases in which the amplitude is sufficiently large to determine them, but of course when the amplitudes are very small there are great uncertainties in the values of the epochs as brought out in the analysis, and a nice agreement cannot be expected.

M TIDE.

| | 1876. | 1877. | 1878. | Mean. | Sandy Hook. |
|---|---|---|---|---|---|
| $A_1 =$ | 0.023 | 0.027 | 0.035 | 0.028 | 0.025 |
| $\epsilon_1 =$ | 125° | 16° | 348° | ---- | ---- |
| $A_2 =$ | 2.153 | 2.147 | 2.152 | 2.149 | 2.246 |
| $\epsilon_2 =$ | 231°.8 | 230°.5 | 230°.6 | 231°.0 | 217°.0 |
| $A_3 =$ | 0.023 | 0.029 | 0.018 | 0.023 | 0.027 |
| $\epsilon_3 =$ | 210° | 206° | 189° | 202° | 202° |
| $A_4 =$ | 0.084 | 0.075 | 0.086 | 0.082 | 0.021 |
| $\epsilon_4 =$ | 334° | 329° | 328° | 330° | 335° |
| $A_6 =$ | 0.066 | 0.066 | 0.071 | 0.068 | 0.052 |
| $\epsilon_6 =$ | 90° | 85° | 82° | 86° | 348° |

S TIDE.

| | | | | | |
|---|---|---|---|---|---|
| $A_1 =$ | 0.033 | 0.045 | 0.050 | 0.042 | 0.032 |
| $\epsilon_1 =$ | 242° | 223° | 238° | 234° | 235° |
| $A_2 =$ | 0.408 | 0.416 | 0.427 | 0.417 | 0.455 |
| $\epsilon_2 =$ | 254°.7 | 256°.2 | 260°.5 | 257°.1 | 245°.9 |
| $A_3 =$ | 0.045 | 0.037 | 0.043 | 0.042 | 0.045 |
| $\epsilon_3 =$ | 99° | 87° | 87° | 91° | 77° |
| $A_4 =$ | 0.036 | 0.051 | 0.036 | 0.041 | 0.038 |
| $\epsilon_4 =$ | 71° | 61° | 80° | 70° | 69° |

K TIDE.

| | | | | | |
|---|---|---|---|---|---|
| $A_1 =$ | 0.317 | 0.322 | 0.322 | 0.320 | 0.334 |
| $\epsilon =$ | 105°.5 | 106°.3 | 106°.0 | 105°.9 | 90°.1 |
| $A_2 =$ | 0.129 | 0.118 | 0.114 | 0.120 | 0.129 |
| $\epsilon_2 =$ | 66°.8 | 51°.8 | 37°.0 | 51°.9 | 37°.4 |

O TIDE.

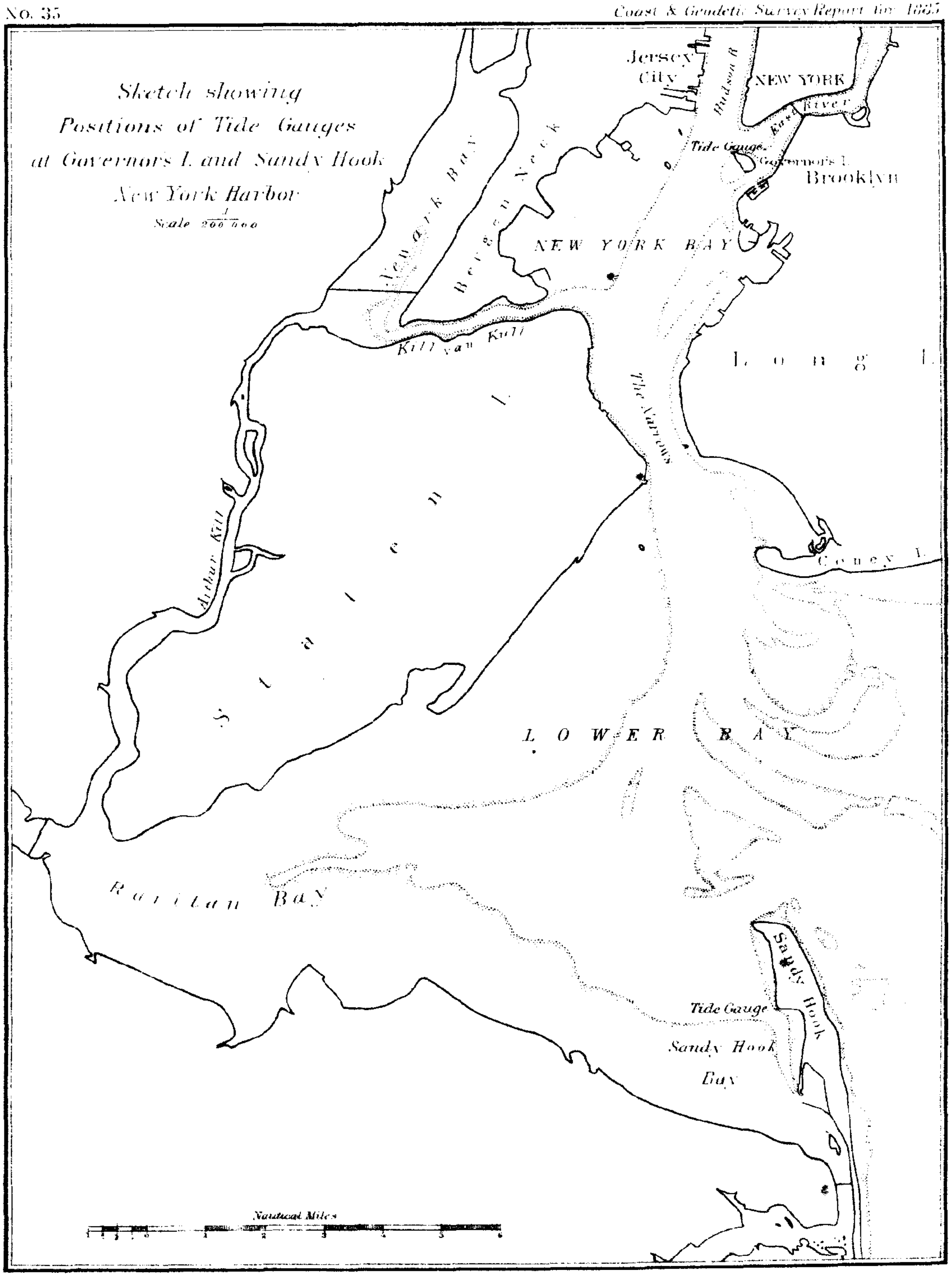
| | | | | | |
|---|---|---|---|---|---|
| $A_1 =$ | 0.163 | 0.150 | 0.156 | 0.156 | 0.170 |
| $\epsilon_1 =$ | 108°.8 | 99°.6 | 101°.1 | 103°.2 | 96°.5 |

P TIDE.

| | | | | | |
|---|---|---|---|---|---|
| $A_1 =$ | 0.107 | 0.115 | 0.093 | 0.105 | 0.103 |
| $\epsilon_1 =$ | 102°.9 | 105°.6 | 103°.9 | 104°.1 | 103°.8 |

L TIDE.

| | | | | | |
|---|---|---|---|---|---|
| $A_2 =$ | 0.100 | 0.114 | 0.096 | 0.103 | 0.092 |
| $\epsilon_2 =$ | 64° | 67° | 52° | 61° | 31° |


Sketch showing
Positions of Tide Gauges
at Governors I. and Sandy Hook
New York Harbor
Scale 1/200 000
Jersey City
Hudson R.
NEW YORK
East River
Tide Gauge
Governor's I.
Brooklyn
Newark Bay
Bergen Neck
NEW YORK BAY
Kill van Kull
Long I.
The Narrows
Arthur Kill
Staten I.
Coney I.
LOWER BAY
Raritan Bay
Sandy Hook
Tide Gauge
Sandy Hook Bay
Nautical Miles

***Analysis*—Continued.**

N TIDE.

| | 1876. | 1877. | 1878. | Mean. | Sandy Hook. |
|---|---|---|---|---|---|
| $A_2$ = | 0.461 | 0.482 | 0.497 | 0.480 | 0.490 |
| $\epsilon_2$ = | 210°.7 | 206°.5 | 210°.8 | 209°.3 | 198°.7 |

$\nu$ TIDE.

| | | | | | |
|---|---|---|---|---|---|
| $A_2$ = | ---- | ---- | 0.155 | ---- | 0.105 |
| $\epsilon_2$ = | ---- | ---- | 203° | ---- | 198° |

HEIGHT OF MEAN LEVEL.

| | | | | | |
|---|---|---|---|---|---|
| $A_0$ = | 4.536 | 4.665 | 4.796 | 4.666 | ---- |

It was not thought worth while to extend the analysis to several other smaller components of which the amplitudes are less than one inch in the Sandy Hook tides, since, on account of the near agreement of those above, mostly with the amplitudes and epochs of the Sandy Hook tides, there could be no sensible difference in these smaller components.

If we take the amplitudes and epochs of the four principal semi-diurnal components and likewise of the three diurnal components, for both Governor's Island and Sandy Hook, we have the following relations between them:

***Semi-diurnal components.***

| | $M_2$ | | $S_2$ | | $K_2$ | | $N_2$ | |
|---|---|---|---|---|---|---|---|---|
| | A | $\epsilon$ | A | $\epsilon$ | A | $\epsilon$ | A | $\epsilon$ |
| | | ° | | ° | | ° | | ° |
| Governor's Island. | 2.149 | 231.0 | 0.417 | 257.1 | 0.120 | 51.9 | 0.480 | 209.3 |
| Sandy Hook. | 2.246 | 217.0 | 0.455 | 245.9 | 0.129 | 37.4 | 0.490 | 198.7 |
| Difference. | 0.097 | 14.0 | 0.038 | 11.2 | 0.009 | 14.5 | 0.010 | 10.6 |

***Diurnal components.***

| | $K_1$ | | $O_1$ | | $P_1$ | |
|---|---|---|---|---|---|---|
| | A | $\epsilon$ | A | $\epsilon$ | A | $\epsilon$ |
| | | ° | | ° | | ° |
| Governor's Island. | 0.320 | 105.9 | 0.156 | 103.2 | 0.105 | 104.1 |
| Sandy Hook. | 0.334 | 90.1 | 0.170 | 96.5 | 0.103 | 103.8 |
| Difference. | 0.014 | 15.8 | 0.014 | 6.7 | 0.002 | 0.3 |

If to the amplitudes of Governor's Island we add one-twentieth part we get those of Sandy Hook, in both the diurnal and semi-diurnal components, within one-fifth of an inch, and much less, except in the case of the semi-diurnal solar component, and the greatest difference without this reduction, which is in the case of the mean semi-diurnal lunar component, is only 0.097 of a foot.

In the epochs the difference is 14° for the mean lunar semi-diurnal component, which should have much the greatest weight in the determination on account of its comparatively large amplitude, but the average of all is 12°.6. In the principal diurnal component it is 15°.8, though in the two other very small components, with amplitudes so small that the epochs cannot be accurately brought out in the analysis, they are much less. Putting, therefore, the general difference of the epochs for both diurnal and semi-diurnal components at 14°, as given by the principal semi-diurnal component, this gives 28 lunar or about 29 solar minutes for the time that the tide occurs at Governor's Island after the time of the tide at Sandy Hook. Considering the small difference in the amplitudes of the components of the two stations, this is the only correction required to reduce the tide-predictions of Sandy Hook to those of Governor's Island with sufficient accuracy for any practical purposes; but if thought desirable the height of the tide above or below mean level can be diminished one-twentieth, a correction which would amount on the average to one-tenth of a foot.

These results, therefore, show that it will be unnecessary to make separate tide-predictions by means of the machine, or otherwise, for both Sandy Hook and Governor's Island, but that the latter may be obtained from the former with sufficient accuracy by simply adding 29 minutes to the times.

The heights of mean level, $A_0$, above the zero of the tide-gauge, indicate that this zero changed its level at the rate of 0.26 feet, or about 3 inches, in two years, as there seems to be a gradual increase in the values of $A_0$ for the several years.

### DETERMINATION OF GENERAL CONSTANTS.

In the tidal theory there are certain constants which have to be determined from observation for each tide-station, as explained in Appendix No. 11 of the Report of the Coast and Geodetic Survey for 1878. From the theoretical relations of the three principal diurnal components given in section 31 of that Appendix we get from the results of the analysis for Governor's Island the following three equations:

$$0.320 - 0.6\,\delta\mu = (.5306 - 13.1\,\delta\mu)\,(1 + .230\,E)\,A_0$$
$$.157 = .3813\,(1 - .230\,E)\,A_0$$
$$.105 = (.1730 - 13.6\,\delta\mu)\,(1 + .196\,E)\,A_0$$

The solution of these equations gives

$$\delta\mu = -.0005 \qquad A_0 = 0.505 \qquad E = 0.788$$

In making out the preceding conditions it was assumed that the moon's mass $\mu$ is equal 0.0125 of the earth's mass. The preceding conditions give a correction for this assumed mass of $\delta\mu = -.0005$. With this correction we get

$$\mu = 0.0125 - .0005 = 0.012 = \frac{1}{83}$$

for the moon's mass. This, we have reason to think, is about its true mass, but the result must be regarded as being in some measure accidental, for the amplitudes of the diurnal tide are too small in the Atlantic Ocean to obtain an accurate determination of the moon's mass; and, besides, these relations are generally disturbed by shallow-water components of the same period, where there are sensible components of this sort, as there are, except in very deep water.

From the relations of the first two equations in section 32 of the Appendix referred to above, we get with the epochs of $K_1$ and $O_1$ in the preceding results

$$105°.9 = L_0 + 13°.18\,G$$
$$103°.2 = L_0 - 13°.18\,G$$

From these we get $L_0=104^\circ.5$ and $G=0.1$. From the first of these we get

$$\frac{104^\circ.5}{14^\circ.492}=7 \text{ hours nearly}$$

for the mean time by which the diurnal tide follows the upper transit of the mean moon. The value of G, above, indicates that the maximum of the diurnal tide follows the maximum of the forces by 0.1 of a day.

From the relations of section 33 in the Appendix, referred to above, we get, with the amplitudes of these components in the preceding results,

$$.1931\ c=(.4852-36.2)\ (1+.425\ E)$$
$$.0573\ c=(.1256-3.2\ \delta\mu)\ (1+.460\ E)$$
$$.2218\ c=\ .1922\ (1-.228\ E)$$

The solution of these equations gives

$$\delta\mu=.0025 \qquad c=1.0750 \qquad E=-1.117$$

The first of these, as a correction for the moon's mass, gives

$$\mu=0.0125+.0025=0.015=\frac{1}{67}$$

for the moon's mass. The preceding conditions, which are essentially those used by Laplace, have always given a mass too large, the mass obtained by Laplace being about $\frac{1}{75}$. But the declination inequality which enters into these conditions is only 1.5 inches in amplitude, and hence it is too small to base a reliable determination upon it.

The constant $c$ being greater, as usual, than unity, indicates that the amplitudes of the smaller component, in being superimposed upon the mean and principal lunar component, are decreased about one-thirteenth, from the effect of friction being as a power greater than the first power of the velocity.

From the relations of the first two equations of section 34 of the same Appendix, we get

$$231^\circ.0 = L_0$$
$$257^\circ.1 = L_0 + 24^\circ.4G.$$

With the value of $L_0$ in the first equation, we get from the second $G = 1.07$, which indicates that the maximum of the semi-diurnal tides follows the maximum of the forces by 1.07 of a day.

With the value of $L_0$, we get

$$\frac{231^\circ.0}{28^\circ.984} = 7.97 \text{ hours} = 7^h\ 59^m$$

as the time by which the high-water of the lunar semi-diurnal component follows the transit of the mean moon over the meridian.

None of the preceding general constants differs much from those obtained in the same manner from the results of the analysis of Sandy Hook.

I have the honor to be, very respectfully, yours,

WILLIAM FERREL.

Prof. J. E. HILGARD,
*Superintendent Coast and Geodetic Survey.*

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# APPENDIX No. 14.

## REPORT ON DEEP-SEA CURRENT WORK IN THE GULF STREAM.

By Lieut. J. E. PILLSBURY, U. S. N., Assistant.

### LETTERS OF INSTRUCTION.

COAST AND GEODETIC SURVEY OFFICE,
*Washington, January* 27, 1885.

SIR: As soon as the steamer Blake and the hydrographic party under your charge are ready, you will please proceed to the Straits of Florida and execute the following hydrographic work:

I. Run lines of soundings, &c., from the east coast of Florida and in the northwest Providence Channel, according to the scheme that will be furnished to you.

II. Obtain a series of observations for currents in the Gulf Stream between Cape Florida and Gun Cay, Bahama Banks, followed by a similar series between Cape San Antonio and Yucatan; this to be followed by other observations at the first station.

The latter observations need only be taken at part of the stations first occupied, but should be made at another phase of the moon, in order to study, as far as practicable, such tidal action as may exist.

You will endeavor to reach Hampton Roads before July 1.

The Hydrographic Inspector will furnish you with projections and other data requisite for the execution of the work.

Yours, respectfully,

J. E. HILGARD,
*Superintendent.*

Lieut. J. E. PILLSBURY, U. S. N.,
*Assistant Coast and Geodetic Survey,*
*Commanding Steamer Blake, Navy-Yard, Washington D. C.*

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### DETAILED INSTRUCTIONS.

COAST AND GEODETIC SURVEY OFFICE,
*Washington, January* 26, 1885.

DEAR SIR: In carrying out the instructions of the Superintendent dated January 27, instant, you will be guided as far as possible by the following considerations: In running the lines of soundings on the Florida coast and in the northwest Providence Channel it is desirable to take serial temperatures in crossing the Gulf Stream, but in the event of bad weather coming on, necessitating an abandoning of any line, it is not advisable to expend much coal in the endeavor to execute this part of the work, as the primary object of the season will be to make complete current observations, and nothing should be allowed to hazard the success of that undertaking that can be foreseen.

In taking the current observations it is desired to obtain a complete series at five or seven stations across the Gulf Stream between Cape Florida and Gun Cay, Bahama Banks, of surface, fifty fathoms, and at some depth between that and the bottom, occupying each station twenty-four or more hours at points at which it is possible to anchor.

Between Cuba and Yucatan the depth of water will probably prevent anchoring in a part of the passage about sixty-five miles in width. On this part you will make at least one drifting observation, making three trials from the same point, with buoys for surface-currents and also for sub-currents at fifty or more fathoms depth.

One series in the Straits of Florida and one to the westward of Cuba are necessary, but it is very desirable also to make a second trial in the former, occupying one of the first stations at a different phase of the moon. In this second trial the weather will probably be more settled, and it is advisable to endeavor to make observations at one point for a long interval rather than to occupy more stations for shorter lengths of time.

Very respectfully,

C. M. CHESTER,

*Commander, U. S. N., and Hydrographic Inspector Coast and Geodetic Survey.*

Lieut. J. E. PILLSBURY, U. S. N.,
*Commanding Steamer Blake, Washington, D. C.*

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REPORT.

U. S. COAST AND GEODETIC SURVEY,
*Steamer Blake, October* 5, 1885.

SIR: I have the honor to make the following report of the season's work at Gulf Stream current observations, in obedience to the instructions of the Superintendent, dated January 27. As this is the first season in which the party under my charge has been engaged in observations of this character, and as I believe it is the first attempt by any party to use the methods which were used by us, and also because I think that the student of the results should have a full knowledge of the methods, I venture, even at the risk of submitting a rather voluminous report, to explain the instruments used to obtain the observations and the manner of using them.

The object of the cruise was to anchor in the deep water of the Gulf Stream, and to observe the currents from the vessel so anchored. The first thing therefore to do, was to devise a method of anchoring the vessel expeditiously, with certainty, and with safety to the vessel and appliances. The Blake was formerly fitted with dredging gear, and for the sake of economy all the parts of this apparatus which could be used were incorporated in the arrangements made for anchoring. Without stopping to explain the reasons for discarding various ideas which were presented for overcoming the enormous strains in anchoring, or to give the reasons why certain other ideas were adopted, I will at once give a description of the gear used. It was thought to be absolutely necessary to relieve the sudden strain (due to the motion of the vessel) on the anchoring cable. To do this a heavy spar or boom (*s*, illustration 36, fig. 3) was attached by a goose-neck to the pawl-bitt (*t*) in the bow. This boom was held up by a steel-wire rope or topping-lift (*u*) at an angle of about 45°. The topping-lift rove through a large block (*v*) at the masthead, and thence through another large block on the deck, the same distance abaft the mast that the end of the boom was forward of it. At the end of the lift abaft the block was attached an arrangement of rubber buffers about 8 feet long, into which was hooked a powerful purchase. It will be seen that upon any weight coming on the end of the boom the strain was transferred by straight thrust to the pawl-bitt, a straight thrust downward on the mast, and a pull forward on the rubber buffers compressing them.

This arrangement worked admirably with great strains, but the pitching of the vessel, causing the wire-rope topping-lift to continually move the sheaves of the two blocks over which it rove, necessitated a change. The rubber accumulator (*w*) was then placed between the boom and the topping-lift, and no trouble was afterward experienced. The anchoring line at first used, or rather tried, was the old dredge-rope of galvanized steel wire. This was a little more than $\frac{3}{8}$ inch

APPARATUS DEVISED BY LIEUT. J. E. PILLSBURY, U. S. N. ASSIST.

FOR OBSERVATIONS OF DEEP-SEA CURRENTS

Fig.1

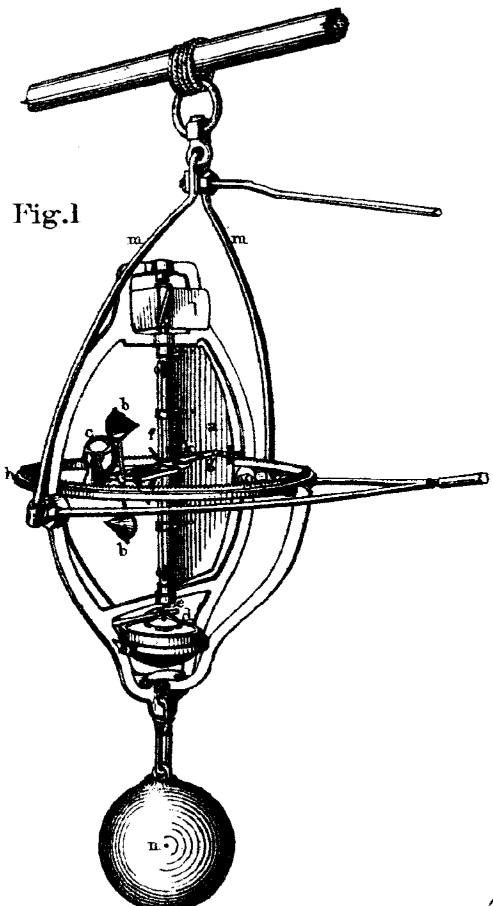
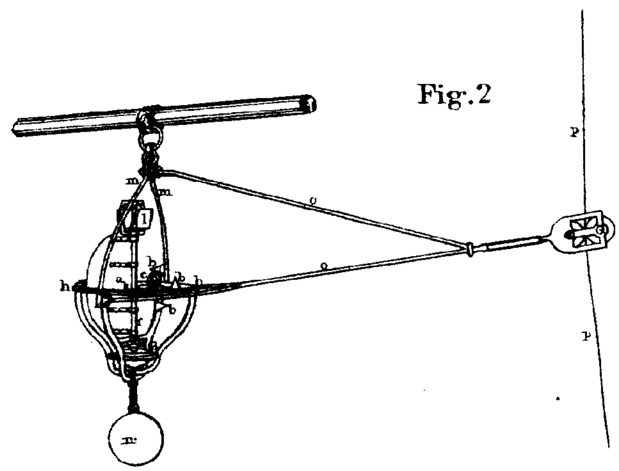
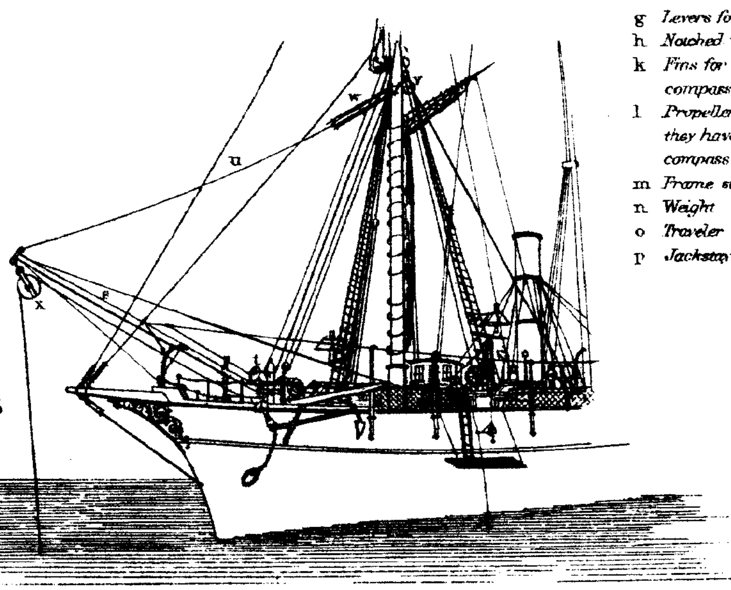


Fig.2



a *Rudder*
b *Speed indicator*
c *Register*
d *Compass bowl*
e *For locking compass needle*
f *Metal stem, connecting* k *and* e
g *Levers for locking rudder in* h
h *Notched ring*
k *Fins for locking rudder and compass needle*
l *Propeller for securing fins after they have locked rudder and compass*
m *Frame supporting Meter by trunnions*
n *Weight*
o *Traveler*
p *Jackstay*

Fig.3



in diameter, but it was soon discarded as being altogether too weak, and another one of $\frac{3}{4}$ and $\frac{5}{8}$ inch diameter used. This line was carried on the old dredge-reel, and led from it to the main reeling engine, and thence through a large leading block (*x*) at the outer end of the boom. The leading blocks were of very heavy make, with sheaves nearly 2 feet in diameter. During the cruise four of the straps of these blocks showed signs of giving way, but the weakness was discovered in time, so that no accident happened.

The operation of anchoring was as follows: The anchor (about 700 pounds in weight) was hung by the anchoring-rope from the end of the boom; at the signal, the men at the reel-brake and reeling-engine brake eased them slightly and allowed the rope to pay out, keeping as nearly as possible an even speed of about 60 or 70 fathoms per minute. Upon the anchor touching the bottom, if it was not paying out faster than this, the rope would stop running, and the register being read, the depth was known. The rope was then paid out slowly, the anchor dragging along the bottom and the ship drifting. If the anchor nipped, the boom would immediately come down more or less, depending upon the current, and the rubber buffers would compress. After a certain scope was out, generally about twice the depth, the rope was secured by a screw clamp, so as to relieve the strain on the reeling-engine and reel. We found that in heaving in we could always tell when the anchor ceased to hold on the bottom by the jumping of the boom. With 800 or more fathoms of rope out, the time of heaving in and securing the anchor was generally less than 45 minutes, including getting in the jackstay (which will be explained further on), the ship's engines being used to steam ahead, so as to ease the strain. With but little current the reeling-engine could heave in the anchoring-rope more than 50 fathoms per minute.

The instrument devised by me to obtain the strength and direction of the currents at any depth consists of a freely-moving rudder of thin metal (*a*). (See illustration 36, figures 1 and 2.) On the front of this, and attached to the rudder, is a set of four metal cones (*b*), placed at the extremities of two arms or spokes which are at right angles to each other. The cones are attached to the arms in such a way that the center of the base of each is equidistant from the center of the spokes, and the apices of all point in the same direction with reference to the spokes, so that when in the current the base of the cone above the axis is towards the current and the apex of the cone diametrically opposite. At the axis of the system is a small shaft turning in points, and by a worm on it turning as it revolves differential wheels (*c*) which register revolutions.

Below the rudder is a compass bowl (*d*) and needle hung in gimbals, and a device (*e*) by which the needle can be lifted and clamped at any time. The rod performing this (*f*) runs through the stem on which the rudder swings, and attached to the same rod a system of levers (*g*), fast to the rudder, clamps its motion in a notched ring (*h*) surrounding the rudder at its middle. Attached to the levers are two horizontal wings or fins (*k*), so arranged that when the instrument is moving upward through the water the pressure of the water on them will clamp the rudder in the notched ring and will lift the compass needle, thus fixing the angle between the rudder and needle, and it remains fixed as long as the instrument has an upward motion. Above the rudder is a small propeller (*l*), arranged in such a way that it will give downward motion to its shaft when the meter has upward motion. The shaft moves through the center of the rudder shaft, and communicates by a small stem to the fins and levers described. The office of this propeller is to lock the fins after they have already clamped the needle and rudder. The whole arrangement worked well, the propeller locking when pulled through a space of 15 fathoms at good speed. The working parts of the meter are inclosed in a strong metal frame, which is hung in trunnions or gimbals (*m*), so that by attaching a weight at its lower end (*n*) it remained in a vertical position.

A value for the divisions on the register or the number of revolutions of the speed indicator per knot could be obtained only by comparisons with the log, and every opportunity was taken to make the comparison. A 21-foot pole was used instead of a log chip, and the meter was lowered to $3\frac{1}{2}$ fathoms. Some of the register readings with currents of about half a knot as shown by the pole were about 100 turns less than with a stronger current, but it was thought that this discrepancy was due to error of pole rather than error of meter, and therefore an average of all was accepted. When it is remembered that 100 turns of the speed indicator in any case are less than one-tenth of a knot, the error of the mean, it will be seen, can be but little. The meter as at first made had a small wing attached to the rudder, which was intended to hold the speed indicator from turning as it was lowered, and another device on the propeller stem for stopping it when the propeller was screwed down in hoisting. The fear of uncertainty of action of the former led to its abandonment, and with the latter the speed of hoisting caused such a variation in the amount of water through which it should be pulled to lock that I was led to discard it also, and to depend altogether on a correction to be applied.

The speed indicator turning a given number of revolutions when passing through a given distance in water, the correction due to hoisting and lowering could be known, and also knowing the speed of the intervening currents between the surface and the point of lowering and the time, the speed of the average current was taken as the one causing the error. The two forces turning the speed indicator were, the upward flow of the water in lowering a given distance and the downward flow in hoisting the same, and the mean horizontal flow from the time of touching the water to the time of stopping, and from the time of starting to hoist until the meter was out of water.

These forces were given a value in terms of revolutions, one being the base of the triangle and the other the perpendicular, and from Bowditch table II the hypothenuse taken. For example, the meter being lowered to 15 fathoms in a mean current of two knots, the time of lowering being 20 seconds and the time of hoisting 25 seconds, the number of revolutions in 45 seconds in a two-knot current would be 26; the number caused by lowering and hoisting through 15 fathoms would be 30. From Bowditch table II we take out 40 as the correction to be subtracted from the register reading to give the number of turns caused by the current at the depth required. In order to test the regularity of revolution, at some of the stations every alternate observation was made at the same depth, under the supposition that in short intervals of time great changes in velocity will not take place. These curves are surprisingly regular, and as the observations were taken for this test at 130 fathoms depth, where the correction is large, the regularity of the curves confirms in a measure the accuracy of the method of correction. It hardly seems possible that there can be an error in the greatest correction of 10 revolutions, which would be less than one one-hundredth of one knot.

In order to prevent the meter from being swept astern by the force of the current the following arrangement was provided: A strong wire called a jack-stay was attached to a boat anchor and three shot and sent to the bottom after the ship's anchor was down. The ship's anchoring rope was then veered so that the vessel dropped astern until the jack-stay wire was up and down; the meter was then attached to this wire by a metal rod and roller called a traveler. It was found that it was very difficult to keep this jack-stay from dragging over the bottom; it was therefore abandoned and the following substituted: When the ship's anchor was on the bottom a piece of line, the length of which depended on the depth of water, was attached to the anchoring rope; at the other end of the line were attached three shot and the jack-stay wire, and both the jack-stay and anchoring rope veered away together. The line was only to act as an anchor on the jack-stay to prevent it dragging, and the weight of the shot to keep it vertical. It was found to work very well.

The meter was lowered attached to the jack-stay wire by the traveler as described. The meter-wire was swept aft, forming a considerable curve with the greater depths, and it was a matter of doubt as to what was the actual depth of the meter below the surface. As deep as 100 fathoms the actual position was found by using a Bassnett's sounding-rod, which is a register of depth depending upon pressure. The proportion of wire to pay out to carry the meter to a certain depth was thus known for all but the greater depths, and with these judgment was used based on the experience of the others. At 65 fathoms from 6 to 30 fathoms more had to be veered. At 130 fathoms, from 20 to 60 fathoms additional.

The actual depth of the meter as given in the record I believe to be correct to within 5 per cent. Greater depths could have been obtained if we could have used heavier weights on the meter, but having but the one instrument I hesitated to do anything that would risk it until the season was successful in the amount and kind of the work attempted. The effect of the bight or middle of the wire being swept aft by the current would be to raise the meter above the depth desired into a stronger current. The register would then show all the fluctuations in the sub-currents that were found on the surface. The trustworthiness of the meter in the sub-currents is shown by the variations, for in many instances the velocity of the sub-current did not increase or decrease with the surface, although in most instances it did.

The most serious difficulties in connection with the meter were these: The compass-needle was gold-plated, silver-plated, and covered with shellac, and in spite of these coverings the rust would come through; the needle became pitted and lost its directive force somewhat, but the latter was corrected by remagnetizing it by means of the Brush dynamo. The rust collected about the pivot and in a short time blunted it so that the needle would hardly move. Whenever a series of observations were completed, and oftentimes in the middle of a series, the meter was taken up and the pivot filed and the needle cleaned. Considerable trouble was experienced from sea-nettles, with which at times it seems the Gulf Stream abounds. These nettles are in appearance about like sewing-silk, and if one of them became attached to the registering gear in any way its motion was retarded. A thorough inspection was made each time, and if there was any doubt of the correctness of the reading of the register the observation was duplicated. Of course there are some errors which *may* have escaped notice, but every care was exercised, and, I believe, the errors are very few. The meter was only experimental—that is to say, it being the first of its kind, there was no certainty that it would work. It was found, however, that with the exceptions mentioned (discarding the arrangement for locking the speed indicator), but one other change was necessary, which was to substitute a propeller with three blades instead of two. One or two additional changes have been made with the new meters, by which they can be taken apart more easily, but these are not essential for accuracy.

The original instructions received from your predecessor, dated January 27, directed me to make a series of observations in the Gulf Stream between Fowey Rocks and Gun Cay, to be followed by similar observations between Cuba and Yucatan, and these to be followed by another series at the first station. I first made five or six trial anchorages for the purpose of testing the gear, and in one of these, near the Yucatan Bank, I discovered evidence of tidal action at 75 fathoms depth. Surmising that perhaps a thoroughly exhaustive examination at Fowey Rocks could not be made, under certain circumstances, in the time allotted, I requested you, through the Hydrographic Inspector, for authority to modify the scheme laid out, if I should deem it for the best interest of the survey, after I had made the first set of observations. On the first set I felt confident that tidal action was noticeable, or at any rate something caused a fluctuation in the strength of the daily flow. I also found that the axis of the stream was not situated near the position supposed by Professor Bache. I found, too, that the strength of the current at some stations was on the surface, while in others it was below, and the contrary results I attributed to lack of observations. My conclusions were, therefore, that exhaustive research at one place would give more positive results to the survey in the cause of science and hydrography than only a partial examination at two places, and I trust that as you examine the record you will consider that my decision was well taken. It was my intention, in laying out a scheme of action to follow in taking the observations, to occupy certain stations at about the first and third quarters of the moon, and again at new and full moons, at exactly the same relative times at each. Could I have had good weather this scheme could have been carried out, but unfortunately good ordinary weather does not mean good anchoring weather in 500 fathoms of water. I found it impossible to follow any scheme exactly. With a moderate easterly breeze the west side of the stream was too rough; with a westerly one the east side had to be avoided. In any place we had to get under way at a squall if it was thought to be heavy. I presume many times that we did get under way we could have remained, but with no duplicate gear on board I was afraid to risk carrying it away until I had made a successful season. I feared, too, in case of an accident, there might be some loss of life. The anchoring rope with a strong current was probably standing a strain of eight or ten tons, the topping-lift and buffers even a greater strain, and with these forces distributed about the ship on both sides and aloft, if anything did go it could hardly miss injuring some one, if not worse. As the season progressed, and the weak points in the anchoring gear had been strengthened as defects appeared, we were at last able to ride through squalls of considerable force without fear of carrying away anything.

I presume in the future there will be many series of current observations across the Gulf Stream, and as this is the narrowest part of the stream, I have given it the name of "Cross Section A" (see sketch 37). The current stations I numbered in succession from west to east—1, 2, 3, 4, 5.

The second time I occupied a station I gave it, in addition to a number, a letter, thus, 1*a*, 2*a*, &c., and the third time, 1*b*, 2*b*, &c. (See sketch 38). The same number indicates observations taken at about the same position. The observations were taken at $3\frac{1}{2}$, 15, 30, 65, and 130 fathoms, and at one or two stations at 2 fathoms and 210 fathoms. During the earlier part of the season the meter was allowed an interval of thirty minutes to register at all depths, except in some instances, when duplicate observations were taken. During the latter part of the season the observations at $3\frac{1}{2}$ fathoms generally took fifteen minutes, at 15 fathoms twenty minutes, and other depths thirty minutes. It was thought that the multiplication of an error in the record of the currents of the upper strata, where the total correction in any event would be small, would give results of the same correctness as in the lower strata, where the corrections are large. In other words, the error at $3\frac{1}{2}$ fathoms multiplied by 4 would be as correct as the error at 130 fathoms multiplied by 2.

The observations for velocity taken on stations 1, 2, 3, 4, and 5 are more liable to error than on the other stations, for the reason that during these observations the propeller was used to lock the velocity apparatus, and an uncertainty exists as to the exact length of time required to completely lock. It is thought, however, that the greatest possible error due to this defect would be expressed by a number of revolutions equal to one-third the depth at which the observation is taken—that is, at 30 fathoms, a possible error of ten revolutions, and so on. On all other stations it is believed that an error of ten revolutions would be excessive on even the greatest depth.

Efforts were made to obtain temperatures at the various depths by attaching thermometers to the meter wire, but they were not successful. The meter wire had a continual vibration when in use, and the index of the thermometers (Miller–Casella) would become shaken up, in some instances even into the bulb. The Negretti–Zambra thermometers were found to turn by the force of the current in too short a time to allow them to register properly. The observations for temperature were consequently given up during the latter part of the season, and it is proposed for next season to have a small rubber arrangement made by which the vibration will be overcome and the thermometers register correctly.

The appended curves of currents at same depths (illustrations 41 to 46, inclusive) represent the actual observations plotted according to time and revolutions of the meter. In strict truth, our whole knowledge of the currents is confined to the observations, and perhaps it is unwarranted to connect the points by curves instead of straight lines. I believe, however, that the curves more truly represent the actual change, or the condition of the currents at any time. On these sheets, near the middle or at the lower edges, are shown the times of the meridian passage (upper transit) of the moon, and the declination each day. All times are local apparent time.

On these curves doubtful observations are inserted, but are connected by light dotted lines. The vertical curves in heavy black broken lines (illustration 43) are the means of the actual observations; those in lighter broken lines are constructed from the means taken from the curves of velocities at the same depth. Illustration 40 shows the approximate declination of the moon during the season, with the position of each station with reference to the declination and phase plotted at its proper place. Illustration 39 shows the profile of the bottom on the upper half, and below is a curve which represents a portion of the monthly variation in velocity of the current at No. 1 station. The points are plotted on the co-ordinates of the moon's declination and velocity, the mean of the surface velocity and the approximate declination for the middle time being taken. From this curve, which includes declinations from about 6° south, increasing to the greatest southing, and thence to about 15° north, it will be seen that apparently the velocity remains nearly constant until the greatest declination is reached, when it increases rapidly until a day or two after the greatest southing, and then decreases again, probably to go through the same fluctuation with northern declination. That this is an invariable rule there are no means of determining with only the meager data thus far obtained, and I have only introduced this curve as an assistance in laying out a scheme for future investigation. That there is a diurnal fluctuation in the velocity of the stream I think cannot be doubted, and it would seem that this daily variation may have given rise to the commonly accepted theory that the axis of the stream varies in position, sometimes daily. The axis of the stream, or the line of maximum velocity, may change somewhat, but the evidence of this change in any of our observations is wanting, with the exception possibly of station No. 5, where a difference of nearly one knot was observed with the same declination of the moon on different months. So many other factors may combine to cause fluctuations, such as

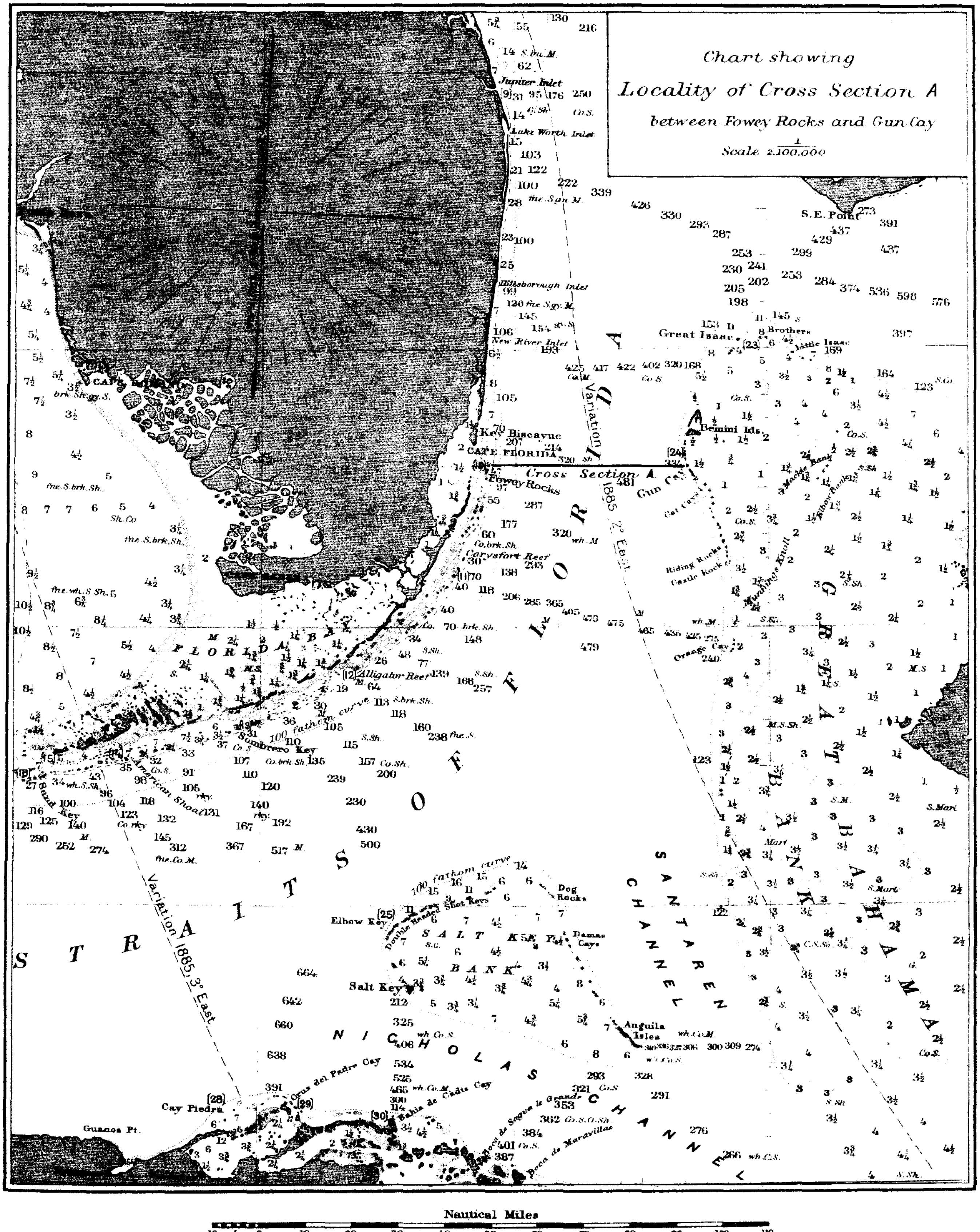
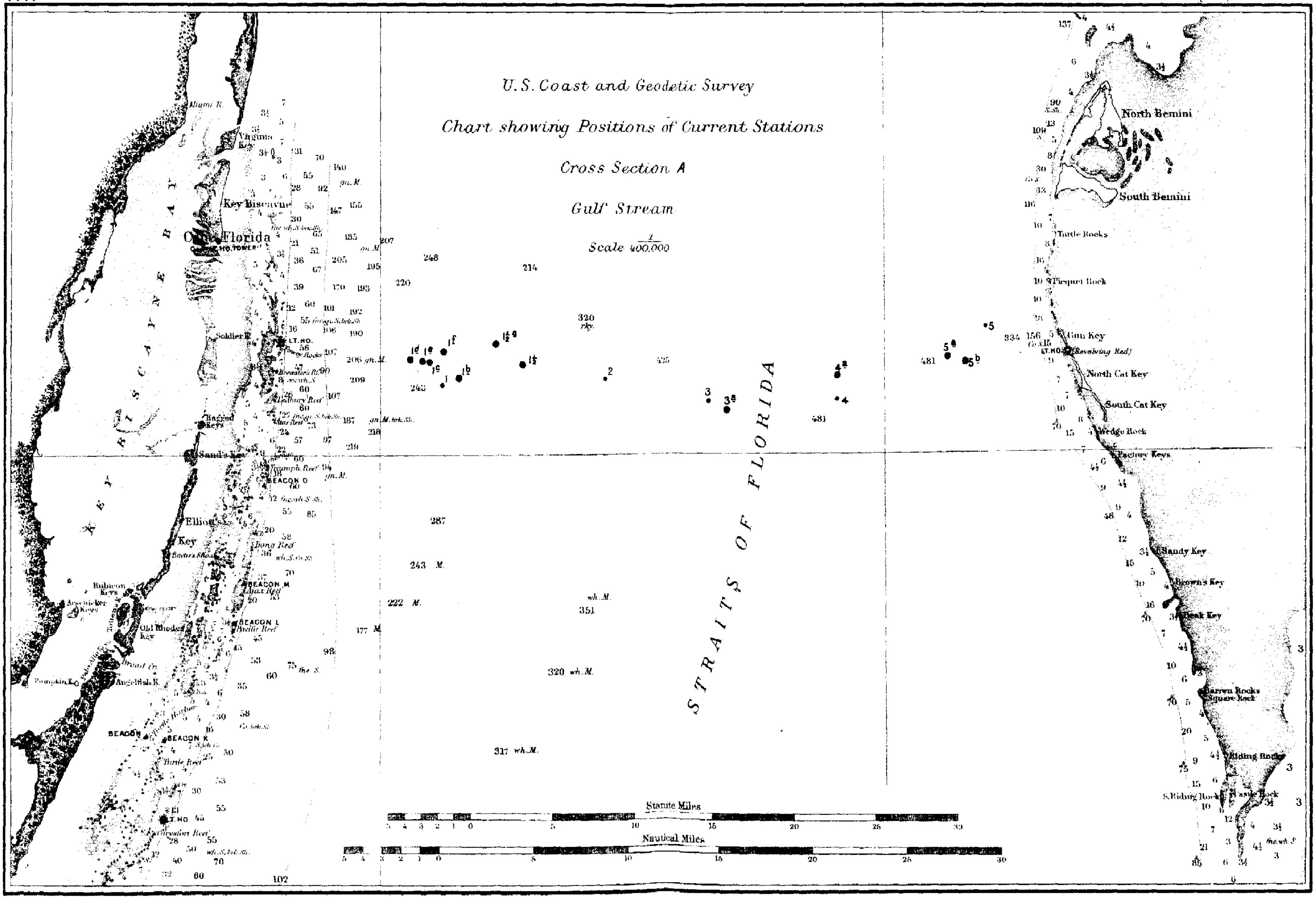


Chart showing
Locality of Cross Section A
between Fowey Rocks and Gun Cay
Scale 1/2.100.000
Jupiter Inlet
Lake Worth Inlet
Hillsborough Inlet
New River Inlet
Key Biscayne
CAPE FLORIDA
Fowey Rocks
Cross Section A.
Gun Cay
Carysfort Reef
Alligator Reef
Sombrero Key
American Shoal
Sand Key
100 fathom curve
Variation 1885 2° East
Variation 1885 3° East
S.E. Point
Great Isaac
Brothers
Little Isaac
Bemini Ids.
Cat Cays
Riding Rocks
Castle Rock
Orange Cay
Mackie Bank
Elbow Bank
Moselle Bank
Muddings Knoll
GREAT BAHAMA BANK
SANTAREN CHANNEL
FLORIDA
STRAITS OF FLORIDA
FLORIDA BAY
SALT KEY BANK
Salt Key
Elbow Key
Double Headed Shot Keys
Dog Rocks
Damas Cays
Anguila Isles
NICHOLAS CHANNEL
Cay Piedra
Guanos Pt.
Cruz del Padre Cay
Bahia de Cadiz Cay
Cayo de Sagua la Grande
Boca de Maravillas
Nautical Miles
10 5 0 10 20 30 40 50 60 70 80 90 100 110


U.S. Coast and Geodetic Survey
Chart showing Positions of Current Stations
Cross Section A
Gulf Stream
Scale 1/400,000
STRAITS OF FLORIDA
BISCAYNE BAY
KEY
Key Biscayne
Cape Florida
Virginia Key
Soldier K.
Ragged Keys
Sand's Key
Elliott Key
Rubicon Keys
Arsenicker Keys
Old Rhodes Key
Angelfish K.
Pumpkin K.
BEACON K
BEACON
LT. HO.
North Bemini
South Bemini
Turtle Rocks
Picquet Rock
Gun Key
North Cat Key
South Cat Key
Wedge Rock
Factory Keys
Sandy Key
Brown's Key
Hawk Key
Barren Rocks
Square Rock
Riding Rocks
S. Riding Rocks
Castle Rock
Statute Miles
Nautical Miles

# DEEP SEA CURRENT WORK
## GULF STREAM

FIG. 1
PROFILE OF BOTTOM
CROSS SECTION A

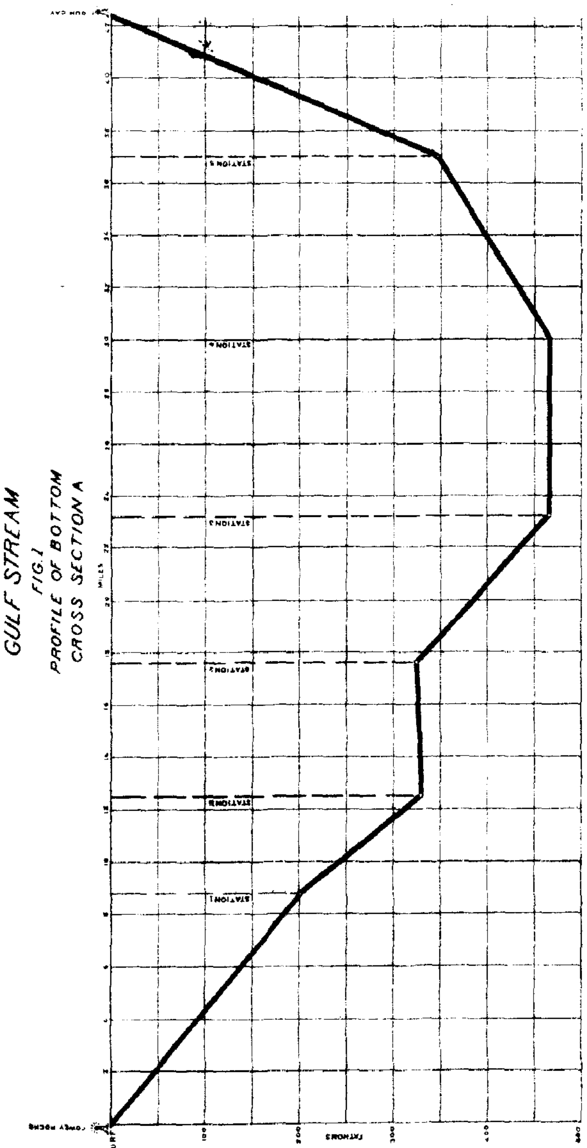
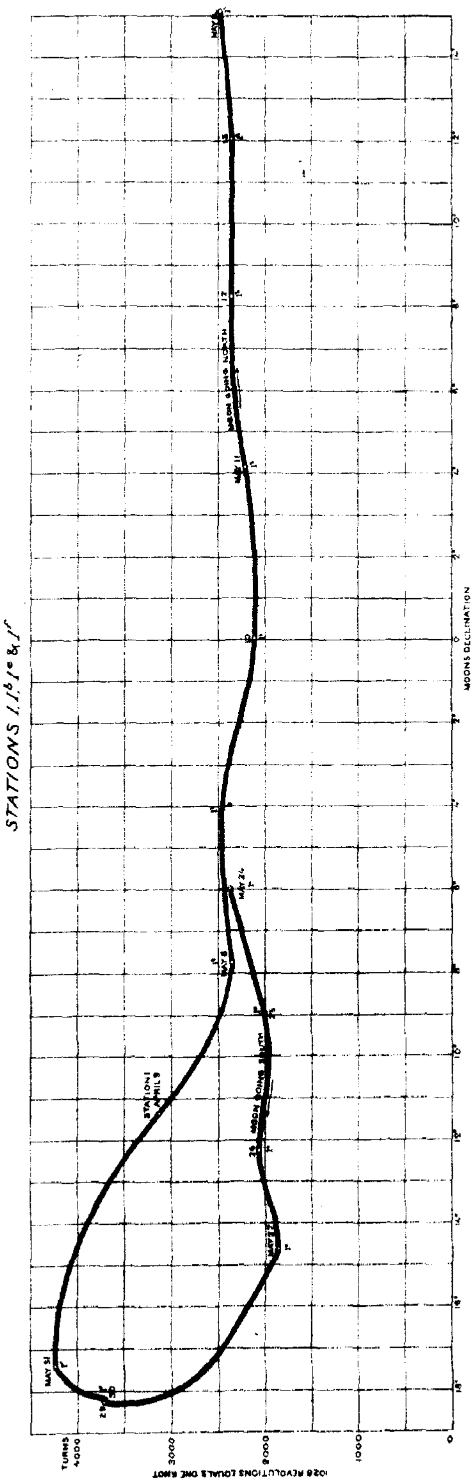
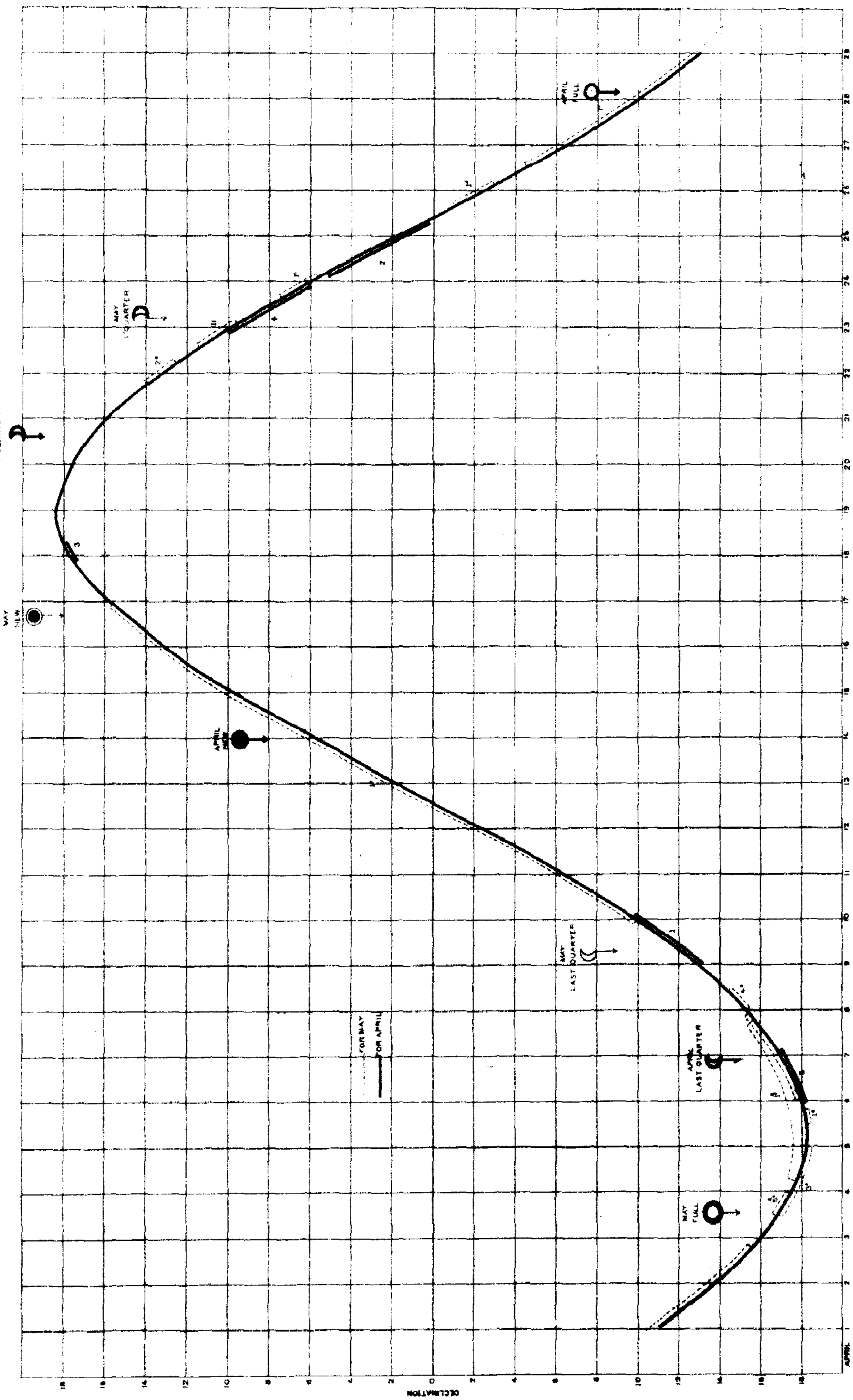



FIG. 2
CURVE SHOWING VARIATION IN VELOCITY OF CURRENTS WITH CHANGES IN MOON'S DECLINATION
STATIONS 1, 1b, 1e & 1f



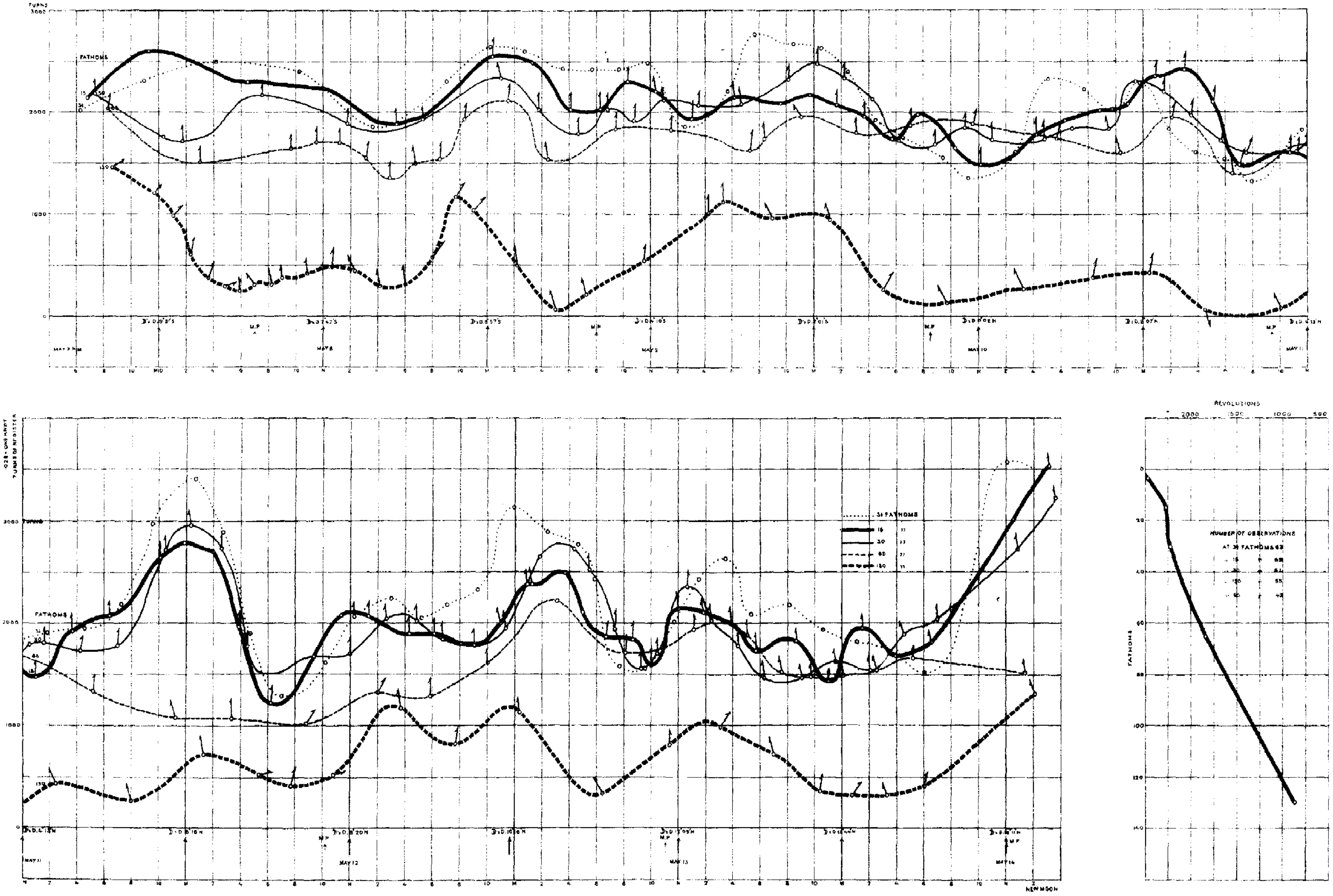
DEEP SEA CURRENT WORK
GULF STREAM
DECLINATION AND PHASE OF MOON AT TIMES OF OBSERVATIONS



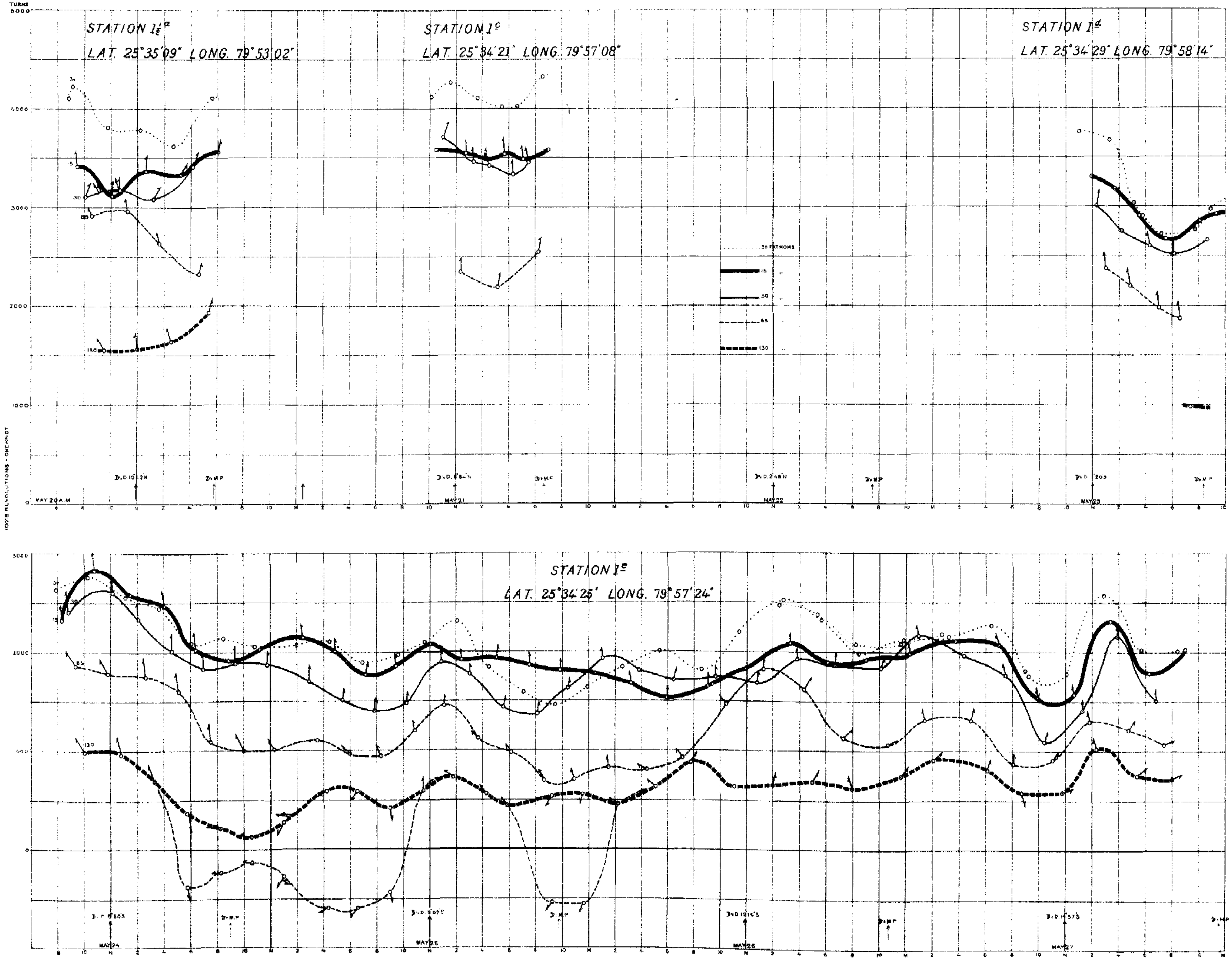
# OBSERVATIONS OF CURRENTS
## GULF STREAM

STATION 1[b] CROSS SECTION A

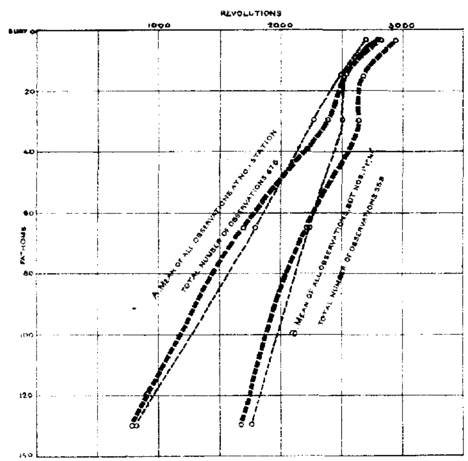
LAT. 25°33'33" LONG. 79°55'25"



# CURVES OF OBSERVATIONS OF CURRENTS
## GULF STREAM

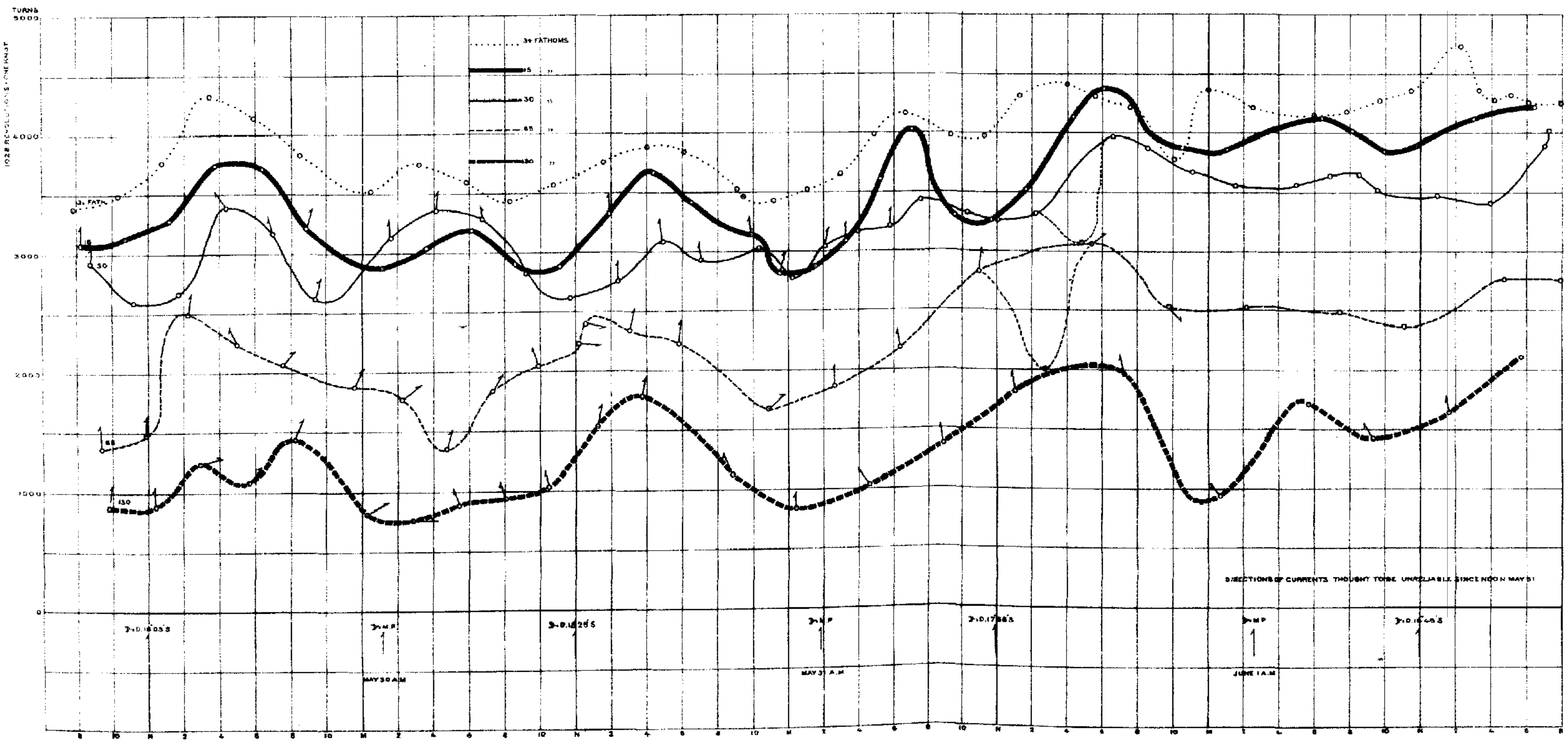


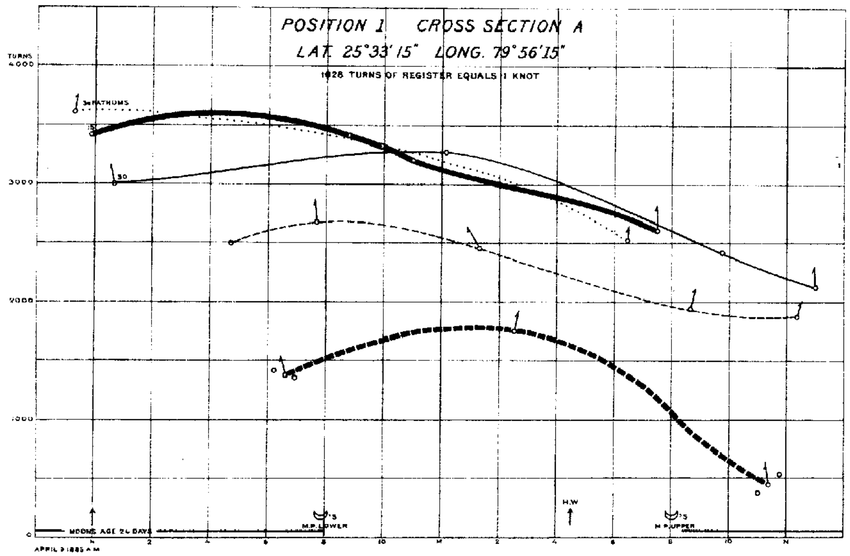
## VERTICAL CURVES

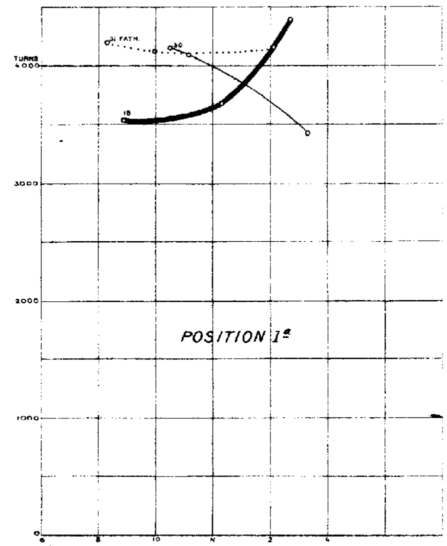



# CURVES OF OBSERVATIONS OF CURRENTS
# GULF STREAM

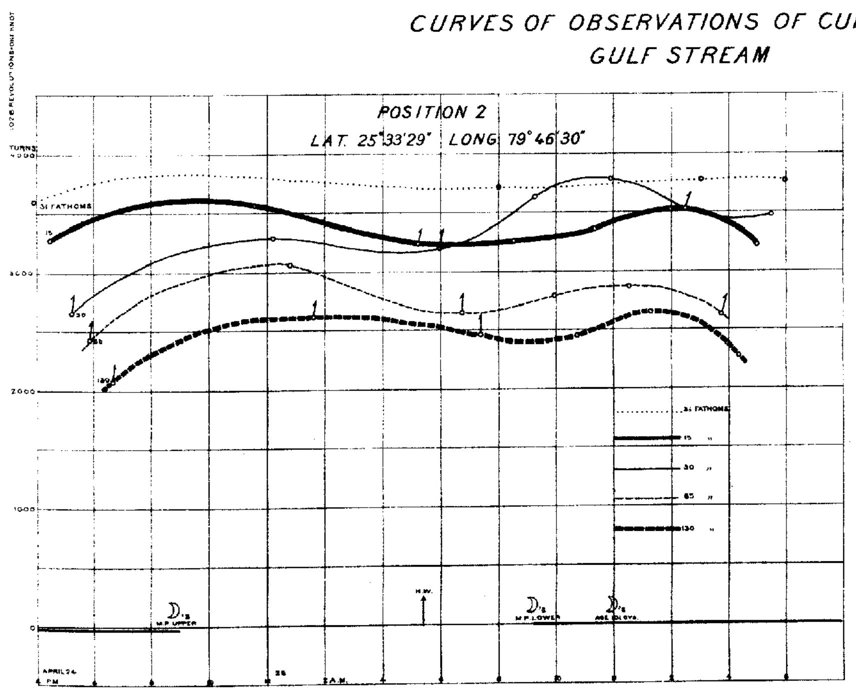
## STATION 1[f]
## LAT. 25° 34′ 48″ LONG. 79° 56′ 11″

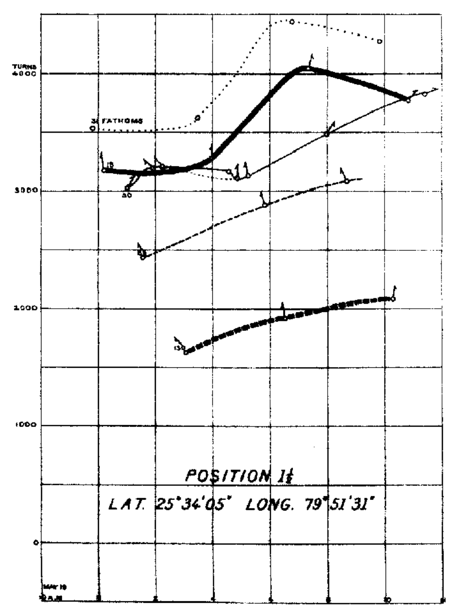


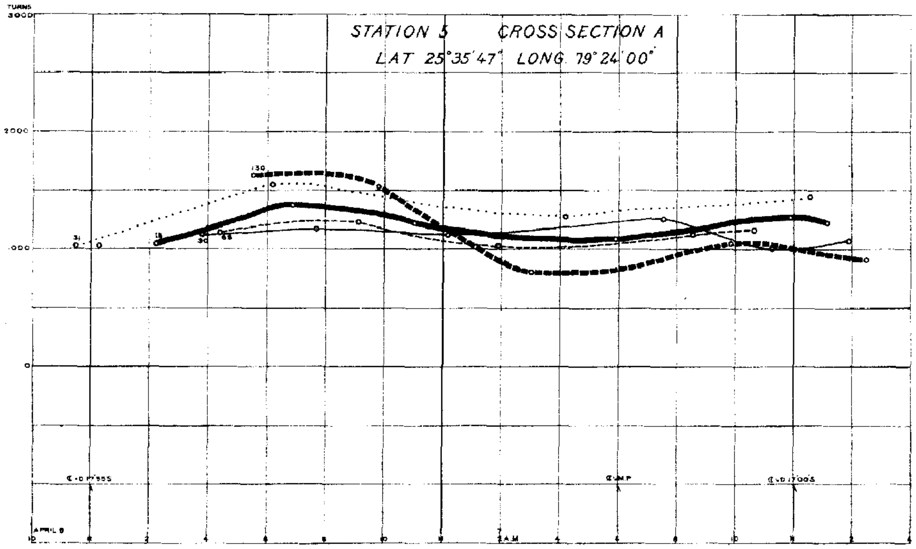


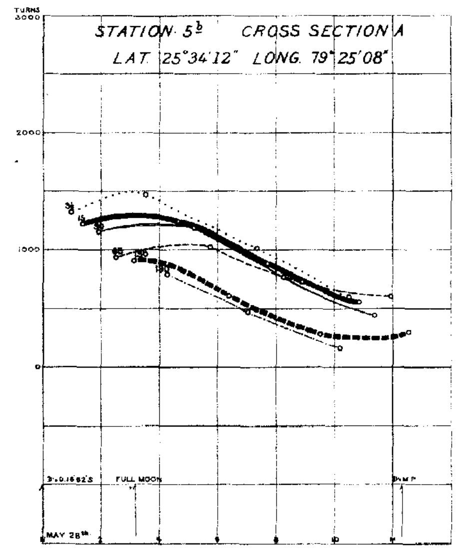




# CURVES OF OBSERVATIONS OF CURRENTS
## GULF STREAM

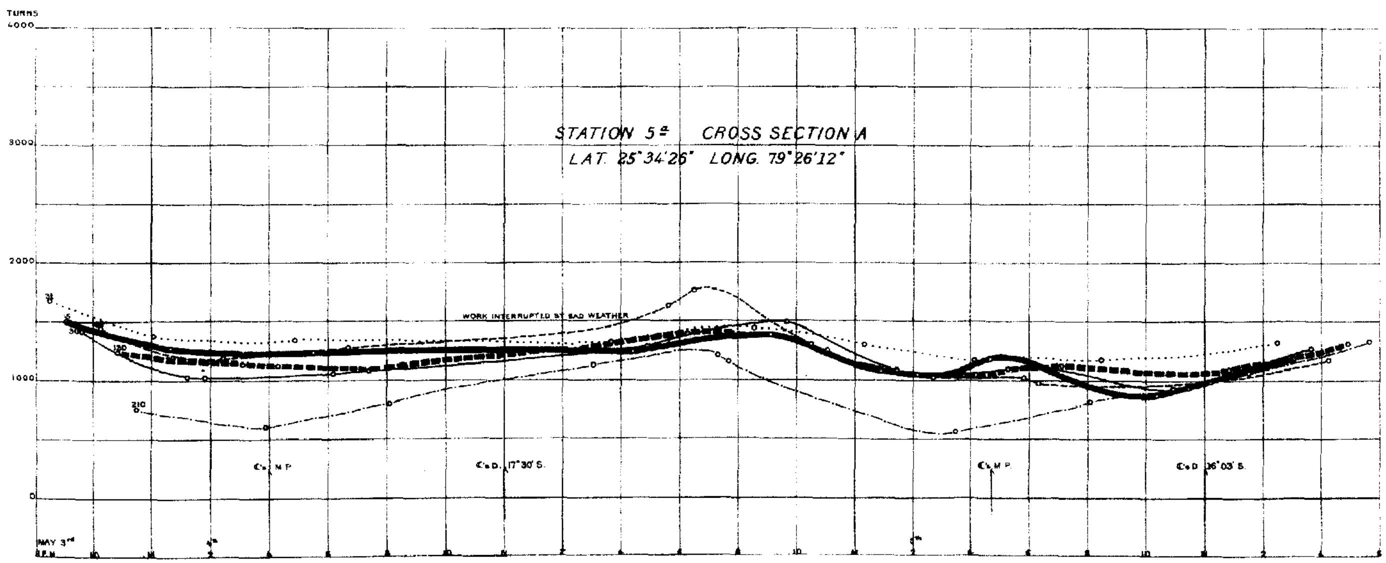


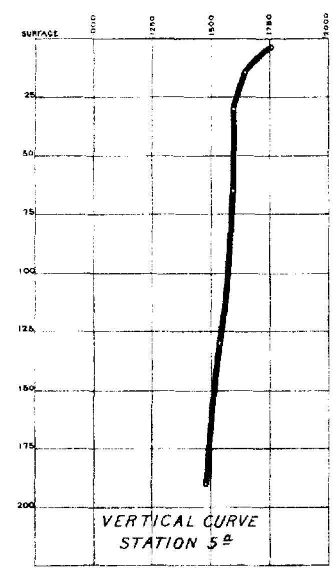





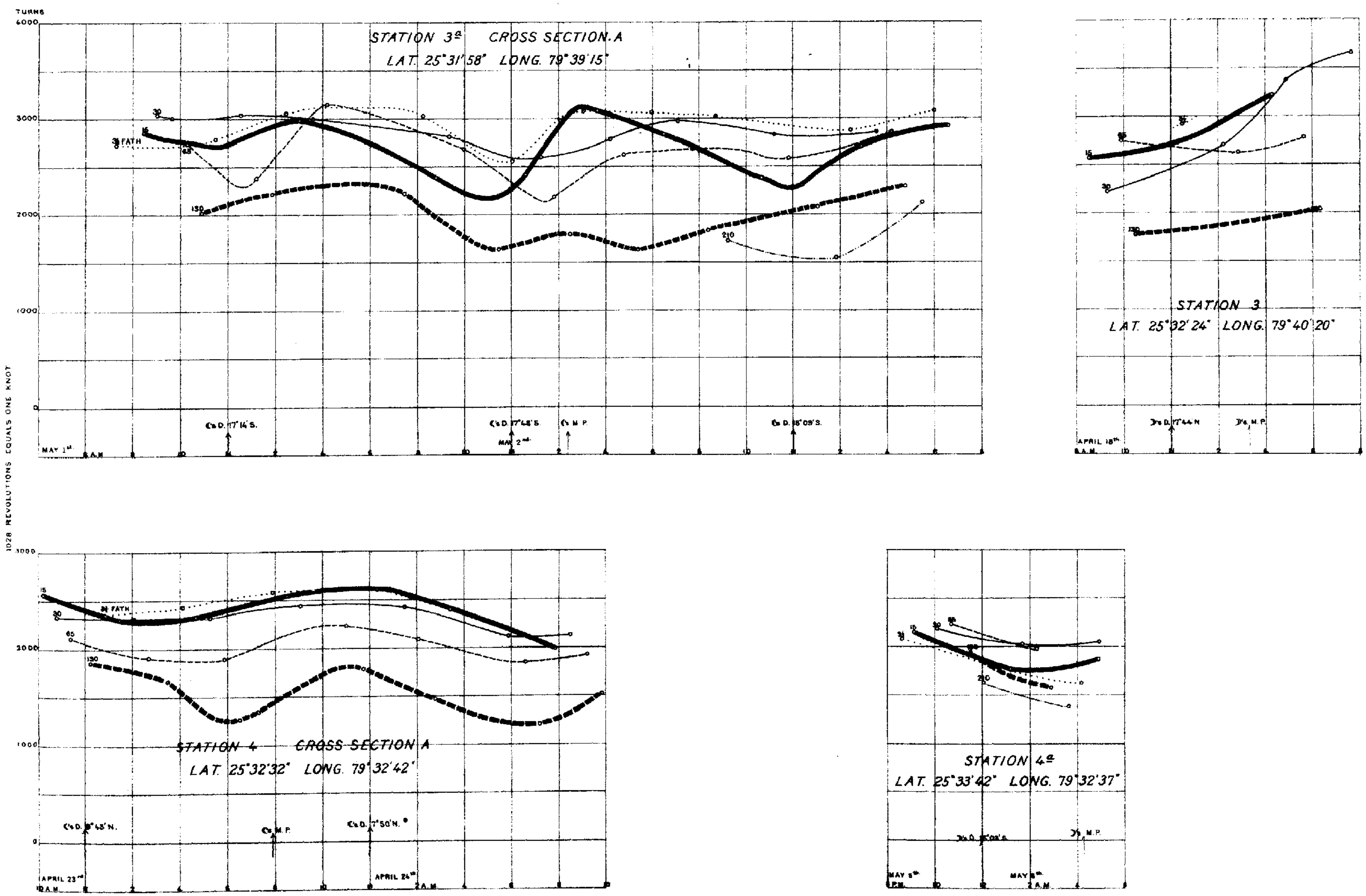




# OBSERVATIONS OF CURRENTS
# GULF STREAM



# OBSERVATIONS OF CURRENTS
## GULF STREAM



strong easterly or westerly winds in the Gulf of Mexico, banking up or reducing the level of the fountain head; the same to the northward and eastward beyond the Little Bahamas; much difference in barometric level between the Gulf of Mexico and the Atlantic, &c., that the evidence from one observation at station No. 5 I do not consider in other light than a variation to the rule. The observations taken for many days at station No. 1 seem to point to a fairly regular flow, and I think it probable that any abnormal cause will affect the whole surface flow, only to retard or accelerate the velocity, and not to change the position of the line of greatest velocity abruptly, or, indeed, to any very great extent.

The velocity of the surface current at times was less than the velocity of the sub-currents. On line 1*b* this is particularly noticeable, where, in every instance, at about the time of the minimum daily velocity, the surface speed fell below that at 15 fathoms, and at times below that at 30 fathoms. In other words, the amount of the daily fluctuation was greatest at the surface. That this was caused by local winds there is no evidence. During this week the winds were light and blowing from no one direction longer than a few hours, and at times when the wind was northerly the velocity was greatest, and when southerly the current was weak. In fact, I could discover no connection between the velocity of the current and the wind, either at the time it was blowing or afterwards, which would cause the variations in the flow of the former. It will be seen from the vertical curves (illustration 43) that (while the surface velocity fell below the sub-surface at times) the mean velocity at the surface was greater than any of those below. The mean depth of the water at the stations used in vertical curve "B" is about 350 fathoms, and for curve "A" 204 fathoms. Continuing the curves it will be seen that they reach zero velocity at about the time they reach the bottom.

This, however, does not seem to be true, for the vertical curve of station 5*a*, shown on illustration 45. At this station the velocities of the sub-currents are more nearly equal to the surface than on any other station, and the daily changes are less. I regret that there are any apparently unreconcilable results in the record obtained, but perhaps when it is studied by some of the scientific gentlemen who have devoted their lives to this and kindred subjects, many points which seem to be inconsistencies now will be solved, and with the addition of the record of one or two more successful seasons at the same place some of the laws governing this wonderful river of the ocean will be made plain.

Too much credit for the success of the season's work cannot be given to the officers of the vessel. They performed their duty in every particular with the greatest care, zeal, and intelligence, and in work so continuous it is a wonder that there are not more erroneous readings or recordings than there seem to be in this record.

Respectfully, &c.,

J. E. PILLSBURY,
*Lieutenant, U. S. N.,*
*Assistant Coast and Geodetic Survey.*

Mr. F. M. THORN,
*Superintendent Coast and Geodetic Survey.*

# APPENDIX No. 15.

## NOTE ON A DEVICE FOR ABBREVIATING TIME REDUCTIONS.

By C. S. PEIRCE, Assistant.

The simple suggestion that I wish to make is that by multiplying the observed times of transit (after applying a provisional correction and subtracting the right ascension) by the cosine of the declination, the field reduction is much facilitated, and the labor of the least-square reduction is decidedly lessened. This arises from two circumstances: First, that the azimuth, level, and collimation coefficients are much quicker taken out, and for northern stars quicker used; and second, that the weights to be assigned to the observations have a small range and are readily applied, while in a rough reduction they may be omitted without disadvantage.

The following are the values of the coefficients:

| | Old way. | New way. |
|---|---|---|
| Azimuth. | $\sin\zeta \sec\delta$ | $\sin\zeta$ |
| Level. | $\cos\zeta \sec\delta$ | $\cos\zeta$ |
| Collimation. | $\pm \sec\delta$ | $\pm 1$ |

The old coefficients have to be taken out of a table of double-entry (which is always disagreeable), and this table extends over eight pages quarto at least. The new coefficients are taken instantly and with greater accuracy from a single-page three-place table of sines and cosines. The old table is of no use for any other purpose, but the little table of trigonometric functions is invaluable for a thousand purposes, and ought to be at every observer's elbow, whether this way of reducing time-observations is used or not. The old coefficients have often three significant figures, even when only two places of decimals are used; but the new ones never exceed unity, and a two-by-two place multiplication table, such as Waldo's, is all that is required with them.

The weights of times of transit of stars of different declinations, according to the researches of Mr. Schott, agreeing with the formula of Dr. Albrecht, are given by the formulæ

$$p = \frac{1}{1 + \left(\frac{36}{63}\right)^2 \tan^2\delta} \text{ for the C. S. large instruments,}$$

$$p = \frac{1}{1 + \left(\frac{63}{80}\right)^2 \tan^2\delta} \text{ for the C. S. small instruments.}$$

The weights for $D = d\cos\delta$, or the residual times multiplied by the cosines of the declinations, are the above multiplied by $\sec^2\delta$, which gives

$$P = \frac{1}{0.663 + 0.337\cos 2\delta} \text{ for the large instruments,}$$

$$P = \frac{1}{0.81 + 0.19\cos 2\delta} \text{ for the small instruments.}$$

Thus, for the large instruments, the weight ranges only from 1 at the equator to 3.06 at the pole, and for the small instruments from 1 to 1.6. The old way of reducing observations, as if all the times had equal weight, is entirely inadmissible even in a rough field-reduction. But after multiplying by cos $\delta$, observations with the small instruments may be treated as of equal weight; while with large instruments, in a not very refined reduction, we may use the rule that $P=1$ from the equator to 41° of declination, $P=2$ from 41° to 70°, and $P=3$ from 70° to the pole. It will never be worth while to use more than one place of decimals for the weights, which are given in the following table:

| Declination. | P | .7 P | Declination. | P | .7 P |
|---|---|---|---|---|---|
| ° | | | ° | | |
| 0 | 1.00 | 0.70 | 50 | 1.65 | 1.15 |
| 5 | 1.01 | 0.71 | 55 | 1.82 | 1.27 |
| 10 | 1.03 | 0.72 | 60 | 2.02 | 1.41 |
| 15 | 1.05 | 0.74 | 65 | 2.24 | 1.57 |
| 20 | 1.09 | 0.76 | 70 | 2.47 | 1.73 |
| 25 | 1.14 | 0.80 | 75 | 2.69 | 1.88 |
| 30 | 1.20 | 0.84 | 80 | 2.88 | 2.02 |
| 35 | 1.28 | 0.90 | 85 | 3.02 | 2.11 |
| 40 | 1.38 | 0.97 | 90 | 3.06 | 2.14 |
| 45 | 1.51 | 1.06 | | | |

In a field-reduction, the unknown chronometer correction being small, the azimuth will be determined in each position by a north and a south star, and the residual D calculated for each star. This is corrected for aberration, and then the simple half difference of the mean residuals in the two positions of the instrument is the collimation, while the half sum (taking only high stars) is the chronometer error multiplied by the cosine of the latitude.

In reducing by least squares, we have the same quantities to calculate as by the old way; but these are obtained in a different manner, as shown by the following formulæ. The multiplications are generally easier by the new method.

*Quantities used in least square work.*

$$p = P \cos^2 \delta$$
$$pA = P \cos \delta \sin \zeta$$
$$pC = \pm P \cos \delta$$
$$pd = PD \cos \delta$$
$$pA^2 = P \sin^2 \zeta$$
$$pAC = \pm P \sin \zeta$$
$$pAd = PD \sin \zeta$$
$$pC^2 = P$$
$$pCd = PD$$
$$\sqrt{p} . d = \sqrt{P} . D .$$

The following is an example: On 1885, April 5, I observed time with transit No. 5 (large size), at Key West, latitude + 24° 33½′. The correction of the chronometer had been found to be

| | |
|---|---|
| April 3, $10^h$ sid. t. | $+ 12^s.07$ |
| April 4, $10^h$ sid. t. | $+ 11^s.34$. |

It was, therefore, supposed to be about + 10ˢ.60 on the 5th at 10ʰ, with a diminution of 0ˢ.01 every twenty minutes. The level was observed as follows:

| | | | Corrected for pivots. | | C |
|---|---|---|---|---|---|
| | h. m. | d. | d. | s. | s. |
| Clamp E. | 9 18 | — 19.1 | — 20.7 | = — 0.420 | } — 0.372 |
| | 9 48 | — 14.3 | — 15.9 | = — 0.323 | |
| Clamp W. | 9 52 | — 22.4 | — 20.8 | = — 0.422 | } — 0.402 |
| | 10 48 | — 20.4 | — 18.8 | = — 0.382 | |

The stars observed, with their constants, were as follows:

| Star. | Approx. time. | δ | | cos δ | cos ζ | sin ζ | p. |
|---|---|---|---|---|---|---|---|
| *Clamp E.* | h. m. | ° | ° | | | | |
| ι Argus. | 9 14 | — 58.8 | + 83.3 | .518 | .117 | + .994 | 2.0 |
| θ Ursæ Majoris. | 25 | + 52.2 | — 27.6 | .613 | .886 | — .463 | 1.7 |
| 10 Leonis Minoris. | 28 | + 36.9 | — 12.3 | .800 | .977 | — .213 | 1.3 |
| ο Leonis. | 35 | + 10.4 | + 14.2 | .984 | .969 | + .245 | 1.0 |
| ε Leonis. | 39 | + 24.3 | + 0.3 | .911 | 1.000 | + .005 | 1.1 |
| μ Leonis. | 46 | + 26.5 | — 1.9 | .895 | .999 | — .033 | 1.2 |
| *Clamp W.* | | | | | | | |
| υ² Hydræ. | 59 | — 12.5 | + 37.1 | .976 | .798 | + .601 | 1.0 |
| γ¹ Leonis. | 10 13 | + 20.4 | + 4.2 | .937 | .998 | + .073 | 1.1 |
| 9 H Draconis. | 25 | + 76.3 | — 51.7 | .237 | .620 | — .785 | 2.7 |
| 41 Leonis Minoris. | 37 | + 23.8 | + 0.8 | .915 | 1.000 | + .014 | 1.1 |
| β Ursæ Majoris. | 55 | + 57.0 | — 32.4 | .545 | .844 | — .536 | 1.9 |

We begin the computation with two zenith stars observed in the two positions. The following gives the data and computation:

| | Clamp E. ε Leonis. | Clamp W. 41 Leon. Min. |
|---|---|---|
| | h. m. s. | h. m. s. |
| Chron. time. | 9 39 10.65 | 10 37 01.63 |
| Assumed correction. | + 10.61 | + 10.58 |
| *t* | 9 39 21.26 | 10 37 12.21 |
| *a* | 9 39 20.92 | 10 37 11.47 |
| *t* — *a* | + 0.34 | + 0.74 |
| (*t* — *a*) cos δ | + 0.31 | + 0.68 |
| *b* cos ζ | — 0.37 | — 0.37 |
| | — 0.06 | + 0.31 |
| Approx. azimuth. | .00 | — 0.01 |
| | — 0.06 | + 0.30 |
| Corrected for aberration. | — 0.08 | + 0.28 |

The mean between the final figures or $\frac{1}{2}(-0^s.08+0^s.28)=+0^s.10$ is the chronometer error multiplied by the cosine of the latitude. Multiplying by the secant, or 1.1, we get $+0^s.11$ as the first approximation to the clock error. We therefore assume that instead of $+10^s.60$ at $10^h$, the error was $+10^s.49$, with a diminution of $0^s.01$ every 17 minutes.

We now proceed to find the azimuth. The data and computations are as follows:

CLAMP E.

| | ι Argus. | θ Ursæ Majoris. |
|---|---|---|
| | h. m. s. | h. m. s. |
| Chron. time. | 9 13 53.76 | 9 25 0.55 |
| Correction. | + 10.52 | + 10.51 |
| $t$ | 9 14 04.28 | 9 25 11.06 |
| $a$ | 9 14 2.98 | 9 25 11.25 |
| $t-a$ | + 1.30 | − 0.19 |
| $(t-a)\cos\delta$ | + 0.67 | − 0.12 |
| $b\cos\zeta$ | − 0.05 | − 0.33 |
| | + 0.62 | − 0.45 |
| sin ζ | − 0.994 | − 0.463 |

The difference between $+0^s.62$ and $-0^s.45$ or $+1^s.07$ is due to the difference between the two sines or $+1.457$. Hence, $a=\frac{1.07}{1.457}=+0^s.734$. Similarly, in the other position, we have the following data and calculations:

CLAMP W.

| | $\upsilon^2$ Hydræ. | 9 H. Draconis. | β Ursæ Majoris. |
|---|---|---|---|
| | h. m. s. | h. m. s. | h. m. s. |
| Chron. time. | 9 59 23.91 | 10 25 9.92 | 10 54 45.70 |
| Corr. | + 10.49 | + 10.47 | + 10.46 |
| $t$ | 9 59 34.40 | 10 25 20.39 | 10 54 56.16 |
| $a$ | 9 59 33.51 | 10 25 21.17 | 10 54 55.93 |
| $t-a$ | + 0.89 | − 0.78 | + 0.23 |
| $(t-a)\cos\delta$ | + 0.87 | − 0.19 | + 0.13 |
| $b\cos\zeta$ | − 0.32 | − 0.25 | − 0.34 |
| | + 0.55 | − 0.44 | − 0.21 |
| Sin ζ | + 0.601 | − 0.785 | − 0.536 |

Combining with $\upsilon^2$ Hydræ, first, 9 H. Draconis, we get

$$a=\frac{+^s.99}{+1.386}=0^s.714$$

and second, β Ursæ Majoris, we have

$$a=\frac{+0^s.76}{+1.137}=0^s.668$$

As the former star has a weight of 3 and the latter of 2, we conclude

$$a=+0^s.696.$$

Applying this value of the azimuth to the high stars, we get the following results:

| | Chron. time. | Corr. | Seconds of $a$ | $t-a$ | $(t-a)$ cos $\delta$ | Level. | Az. | |
|---|---|---|---|---|---|---|---|---|
| *Clamp E.* | h. m. s. | | s. | | | | | |
| 10 Leonis Minoris. | 9 28 01.73 | +10.51 | 12.17 | +0.07 | +0.06 | −0.36 | +0.16 | −0.14 |
| $o$ Leonis. | 34 52.22 | +10.51 | 02.31 | +0.42 | +0.41 | −0.36 | −0.18 | −0.13 |
| $\varepsilon$ Leonis. | 39 10.65 | +10.50 | 20.92 | +0.23 | +0.21 | −0.37 | 0.00 | −0.16 |
| $\mu$ Leonis. | 46 04.68 | +10.50 | 14.91 | +0.27 | +0.24 | −0.37 | +0.02 | −0.11 |
| | | | | | | | Mean. | −0.14 |
| | | | | | Corrected for aberration. | | | 0.16 |
| *Clamp W.* | | | | | | | | |
| $\gamma^1$ Leonis. | 10 13 29.71 | +10.48 | 39.58 | +0.61 | +0.57 | −0.40 | −0.05 | +0.12 |
| 41 Leonis Minoris. | 37 01.63 | +10.47 | 11.47 | +0.63 | +0.58 | −0.40 | −0.01 | +0.17 |
| | | | | | | | Mean. | +0.14 |
| | | | | | Corrected for aberration. | | | +0.12 |

It therefore appears that the collimation is + 0s.14 and the additional chronometer correction + 0s.02, making the correction at 10h, + 10s.51. We now apply these corrections to all the stars, with the following results:

| Star. | $\tau - a$ | $(t-a)$ cos $\delta$ | Az. | Level. | Coll. and Ab. | D | P |
|---|---|---|---|---|---|---|---|
| *Clamp E.* | | | | | | | |
| $\iota$ Argus. | + 1.32 | + 0.68 | − 0.73 | − 0.04 | + 0.12 | + 0.03 | 2 |
| $\theta$ Ursæ Majoris. | − 0.17 | − 0.10 | + 0.34 | − 0.33 | + 0.12 | + 0.03 | 2 |
| 10 Leonis Minoris. | + 0.09 | + 0.07 | + 0.16 | − 0.36 | + 0.12 | − 0.01 | 1 |
| $o$ Leonis. | + 0.44 | + 0.43 | − 0.18 | − 0.36 | + 0.12 | + 0.01 | 1 |
| $\varepsilon$ Leonis. | + 0.25 | + 0.23 | + 0.00 | − 0.37 | + 0.12 | − 0.02 | 1 |
| $\mu$ Leonis. | + 0.29 | + 0.26 | + 0.02 | − 0.37 | + 0.12 | + 0.03 | 1 |
| *Clamp W.* | | | | | | | |
| $\upsilon^2$ Hydræ. | + 0.91 | + 0.89 | − 0.42 | − 0.32 | − 0.16 | − 0.01 | 1 |
| $\gamma^1$ Leonis. | + 0.63 | + 0.59 | − 0.05 | − 0.40 | − 0.16 | − 0.02 | 1 |
| 9 H Draco. | − 0.76 | − 0.18 | + 0.55 | − 0.25 | − 0.16 | − 0.04 | 3 |
| 41 Leonis Minoris. | + 0.65 | + 0.59 | − 0.01 | − 0.40 | − 0.16 | + 0.02 | 1 |
| $\beta$ Ursæ Majoris. | + 0.25 | + 0.14 | + 0.37 | − 0.34 | − 0.16 | + 0.01 | 2 |

Taking the weighted means of D on the two sides, we see that the collimation has to be reduced by 0s.01, while the chronometer correction remains unchanged. We then have for D

| Clamp E. | Clamp W. |
|---|---|
| + 0.02 | 0.00 |
| + 0.02 | − 0.01 |
| − 0.02 | − 0.03 |
| 0.00 | + 0.03 |
| − 0.03 | + 0.02 |
| + 0.02 | |

This concludes the field-reduction, and the magnitudes of the residuals illustrate its superiority over old methods. Finally, we will calculate further corrections by least squares. The quantities for the normal equations are calculated as follows:

| $P \cos^2\delta$ | $P \cos\delta \sin\zeta$ | $\pm P \cos\delta$ | $PD \cos^2\delta$ | $P \sin^2\zeta$ | $\pm P \sin\zeta$ | $PD \cos\delta \sin\zeta$ | $\pm PD \cos\delta$ |
|---|---|---|---|---|---|---|---|
| *Clamp E.* | | | | | | | |
| 0.5 | + 1.0 | + 1.0 | + 0.01 | 2.0 | + 2.0 | + 0.02 | + 0.02 |
| 0.6 | − 0.5 | + 1.0 | + 0.01 | 0.4 | − 0.8 | − 0.01 | + 0.02 |
| 0.8 | − 0.2 | + 1.0 | − 0.02 | 0.1 | − 0.3 | 0.00 | − 0.02 |
| 1.0 | + 0.2 | + 1.0 | 0.00 | 0.1 | + 0.3 | 0.00 | 0.00 |
| 0.9 | 0.0 | + 1.0 | − 0.03 | 0.0 | 0.0 | 0.00 | − 0.03 |
| 0.9 | 0.0 | + 1.0 | + 0.02 | 0.0 | 0.0 | 0.00 | + 0.02 |
| 4.7 | + 0.5 | + 6.0 | − 0.01 | 2.6 | + 1.2 | + 0.01 | + 0.01 |
| *Clamp W.* | | | | | | | |
| 1.0 | + 0.6 | − 1.0 | 0.00 | 0.4 | − 0.6 | 0.00 | 0.00 |
| 1.0 | + 0.1 | − 1.0 | − 0.01 | 0.0 | − 0.1 | 0.00 | + 0.01 |
| 0.2 | − 0.5 | − 0.6 | 0.00 | 1.6 | + 2.1 | − 0.02 | + 0.02 |
| 0.9 | 0.0 | − 1.0 | + 0.03 | 0.0 | 0.0 | 0.00 | − 0.03 |
| 0.6 | − 0.6 | − 1.0 | + 0.01 | 0.5 | + 1.0 | − 0.01 | − 0.02 |
| 3.7 | − 0.4 | − 4.6 | + 0.03 | 2.5 | + 2.4 | − 0.03 | − 0.02 |

The normal equations themselves are:

$$
\begin{array}{rrrrl}
8.4\,t & +\ 0.5\,a & -\ 0.4\,a^1 & +\ 1.4\,c & = +\ 0.02^{s.} \\
0.5 & +\ 2.6 & & +\ 1.2 & = +\ 0.01 \\
-\ 0.4 & & +\ 2.5 & +\ 2.4 & = -\ 0.03 \\
1.4 & +\ 1.2 & +\ 2.4 & +\ 16 & = -\ 0.01
\end{array}
$$

The solution is

$$t = +.001 \quad a = +.003 \quad a^1 = -.012 \quad c = +.001$$

So that the field reduction cannot be improved.

I will add that it seems to me that this mode of reduction will be much more easily understood by inexperienced computers than the old one.

# APPENDIX No. 16.

## ON THE INFLUENCE OF A NODDY ON THE PERIOD OF A PENDULUM.

By C. S. PEIRCE, Assistant.

Suppose a noddy, adjusted to accord with a reversible pendulum, remain on the pendulum-support throughout the experiments to determine gravity. How much can the results be affected by this circumstance?

Let us use this notation:

$l$ and $l'$, the lengths of the single pendulums corresponding to the pendulum and noddy, respectively; that is, in each case the square of the radius of gyration divided by the distance between the center of mass and center of rotation;

$\mu$ and $\mu'$, the ratio of any linear displacement of the support to the angular displacement of the pendulum or noddy required to produce it;

$\tau$ and $\tau'$ the natural periods of pendulum and noddy;

T the period of either harmonic constituent of the motion.

Then, the formula, easily derived from my paper on two pendulums on one support, is:

$$T^2 = \tfrac{1}{2}\left\{\left(1+\frac{\mu}{l}\right)\tau^2 + \left(1+\frac{\mu'}{l'}\right)\tau'^2\right\} \pm \sqrt{\tfrac{1}{4}\left\{\left(1+\frac{\mu}{l}\right)\tau^2 - \left(1+\frac{\mu'}{l'}\right)\tau'^2\right\} + \frac{\mu\mu'}{l\,l'}\tau^2\tau'^2}$$

Any increase of $\tau'$ always produces an increase of T; and of the two values of $T^2$, one is always smaller, the other greater than

$$\left(1+\frac{\mu}{l}\right)\tau^2$$

Consequently, the greatest effect is produced when one value of $T^2$ is as much greater as the other is less than

$$\left(1+\frac{\mu}{l}\right)\tau^2$$

that is, when

$$\left(1+\frac{\mu'}{l'}\right)\tau'^2 = \left(1+\frac{\mu}{l}\right)\tau^2$$

In this case,

$$T^2 = \left(1+\frac{\mu}{l}\right)\tau^2 \pm \sqrt{\left(\frac{\mu\mu'}{ll'}\right)\tau^2\tau'^2}$$

Denote by M and M′ the masses of the pendulum and noddy, respectively, and by $h$ and $h'$ the distance in each between the center of mass and the center of rotation. Then

$$\mu\tau^2 : \mu'\tau'^2 = \frac{Mh}{l} : \frac{M'h'}{l'}$$

and

$$\sqrt{\frac{\mu\mu'}{ll'}\tau^2\tau'^2} = \frac{\mu}{l}\tau^2\sqrt{\frac{\mu'}{\mu}\frac{\tau'^2}{\tau^2}\frac{l}{l'}} = \frac{\mu}{l}\tau^2\frac{l}{l'}\sqrt{\frac{M'h'}{Mh}}$$

Assuming

$$\frac{M'}{M}=\frac{1}{100}, \frac{h'}{h}=\frac{1}{36}$$

for heavy end down, $\frac{1}{12}$ for heavy end up, and $\frac{l}{l'}=20$, it would follow that the effect of the noddy might be as great as $\frac{1}{3}$ of the flexure with heavy end down, and as $\frac{1}{\sqrt{3}}$ times the flexure with heavy end up. But it could not produce a sensible effect in both positions.

# APPENDIX No. 17.

## ON THE EFFECT OF UNEQUAL TEMPERATURE UPON A REVERSIBLE PENDULUM.

By C. S. PEIRCE, Assistant.

The upper part of a pendulum swinging in a room not very lofty is always warmer than the lower part. Let us suppose that the temperature varies uniformly along the length of the pendulum.

A reversible pendulum consists of two parts, (first) the part symmetrical about the middle of the pendulum, and (second) the load, however distributed. We may distinguish letters referring to these two parts by the subjacent indices 1 and 2. Letters without an index may refer to the whole pendulum.

Considering, first, the symmetrical part, it is plain that the inequality of temperature cannot sensibly alter the radius of gyration of this about its center of mass, which depends on the mean temperature only, since the center of mass of this part is at the center of the pendulum. The distance of the center of mass from the supporting knife-edge will, however, be increased, say, by $\sigma$. Then, if M stand for mass, $l$ for the length of the corresponding simple pendulum, and $h$ for the distance of the centre of mass from the point of support, the moment of inertia will be (neglecting $\sigma^2$)

$$Mlh + M_1 l\sigma,$$

that is, it will be multiplied by

$$1 + \frac{M_1}{M}\frac{\sigma}{h}$$

But the moment of gravity will be

$$Mh + M_1\sigma,$$

so that it will also be multiplied by

$$1 + \frac{M_1}{M}\frac{\sigma}{h}$$

and the period of oscillation, which depends on the ratio of the moment of inertia to the moment of gravity, will not be affected.

Let us now consider the load, which we may suppose to be symmetrical about its middle. Denote the distance of its center from that of the pendulum by $\eta$. Let $\delta\tau$ be the excess of the temperature of the upper knife above that of the lower one. Then $\frac{\eta}{l}\delta\tau$ will be the difference of temperature of the center of the load from the mean temperature of the pendulum. It will have the *minus* sign with heavy end down, the *plus* sign with heavy end up. Let $k$ be the coefficient of expansion. Then, every dimension of the load will, owing to the inequality of temperature, be multiplied by

$$1 \mp \frac{\eta}{l}k\delta\tau,$$

where the double sign corresponds to the two positions of the pendulum. The radius of gyration about the center of the load (which we may denote by $\gamma_2$) will be multiplied by the same amount;

and consequently the moment of inertia and the square of the period of oscillation will be multiplied by

$$1 \mp \frac{M_2}{M} \frac{\gamma_2^2}{hl} \cdot \frac{\eta}{l} k\delta\tau$$

The middle of the distance from the supporting knife-edge to the center of the load will be at a distance

$$\mp \tfrac{1}{2}\eta + \tfrac{1}{4}l$$

above the center of the pendulum in the two positions, and this distance will be

$$\pm \eta + \frac{1}{2}l$$

The inequality of temperature will therefore in both positions raise the centre of the load by

$$\tfrac{1}{2}\frac{\eta^2 - \frac{1}{4}l^2}{l} k\delta\tau$$

The moment of inertia will therefore be multiplied by

$$1 \mp \frac{M_2}{M} \frac{\eta + \frac{1}{2}l}{l} \frac{\eta^2 - \frac{1}{4}l^2}{hl} k\delta\tau$$

the moment of gravity will be multiplied by

$$1 \mp \frac{M_2}{M} \frac{1}{2} \frac{\eta^2 - \frac{1}{4}l^2}{hl} k\delta\tau$$

and the square of the period of oscillation will be multiplied by

$$1 \mp \frac{M_2}{M} \frac{\eta}{l} \frac{\eta^2 - \frac{1}{4}l^2}{hl} k\delta\tau$$

In order to make these effects as small as possible, the load should be concentrated as much as possible about one knife-edge. For this purpose, the symmetrical part might be an unloaded tube about $\sqrt{3}$ times the distance between the knife-edges in length. This construction would also have the advantage of eliminating the error due to the flexure of the pendulum staff.

In the case of the Peirce metre pendulums, we have

$\gamma_2^2 = \frac{1}{4}(3\,cm)^2 + \frac{1}{12}(16.03\,cm)^2 = 23.66\,(cm)^2$

$M_2 = 4000$ grams $\quad \eta = 65.63\,cm \quad$ M = 105000 grams

$h_d = 75\,cm \quad h_u = 25\,cm \quad l = 100\,cm \quad k = .00001863 \quad T = 1^s.003$

And the correction to the time of 5000 oscillations with heavy end up, or 15000 with heavy end down, per degree centigrade of difference of temperature between the knife-edges is

$$\pm\ 0^s.00856.$$

In the case of the Peirce yard pendulum,

$\gamma_2^2 = \frac{1}{4}(3\,cm)^2 + \frac{1}{12}(15.19\,cm)^2 = 21.48\,(cm)^2$

$M_2 = 3770$ grams $\quad \eta = 60.68\,cm \quad$ M = 10000 grams

$h_d = 68.58 \quad h_u = 22.86 \quad l = 91.44 \quad k = .00001863 \quad T = 0^s.9594$

and the same correction is

$$\pm\ 0^s.00863.$$

# APPENDIX No. 18.

## TRIBUTE TO THE MEMORY OF HENRY W. BLAIR, ASSISTANT.

By the death of Assistant HENRY WAYNE BLAIR the Coast and Geodetic Survey has lost a young officer of marked ability and high character; one of whom it is not too much to say that had he lived he would have stood among the foremost in rank on the work.

Mr. Blair was born in San Antonio, Texas, December 27, 1851. His father was an officer of the Army, on duty there until shortly before the outbreak of the civil war. He then accompanied his parents to Virginia, their native State, and during the trying years that followed, learned in his boyhood lessons of patience, forbearance, and self-denial that were deeply impressed upon him by the privations and sufferings of those times.

In 1866 he was entered as a cadet at the Virginia Military Institute, and took from the first a leading place in scholarship, graduating in 1870 with high rank. Soon after his graduation he was appointed to an assistant professorship in the Institute, and labored in this position with zeal and success, securing the entire confidence of the faculty. He had, however, always desired a life of greater activity than was open to a teacher, and willingly accepted an appointment offered him on the Survey, entering its service as Aid in January, 1872.

The anticipations of usefulness and distinction which his career as a student and professor had led his friends to entertain for him were not long in being fulfilled. In June, 1878, he was promoted to be Subassistant. Continuing to serve with great credit, and exhibiting unusual aptitude in every branch of the work assigned to him, he was made Assistant in August, 1882, having been previously appointed to a position involving laborious and responsible duty in the office. To the duties of this position he devoted himself with unremitting energy, satisfying not only its routine requirements, but following the bent of his mind for work demanding original investigation. He gave much study to the subject of standards of weight and measure, and prepared for publication, in co-operation with the Superintendent, a report on the progress made in the construction of those standards. He submitted designs for, and directed the construction of, a comparing apparatus for the micrometric comparison of standard line measures from a decimeter to a meter in length. To this apparatus was awarded a diploma at the Southern Exposition held at Louisville, where the Survey was represented by an exhibit under Mr. Blair's charge.

In January, 1884, after returning from this service, he resumed his position in the office. It was in the summer of that year that he was taken with a lingering illness, from which late in the autumn he had apparently recovered. He was on his way to New Orleans to take charge of the exhibit of the Survey at the Cotton Centennial Exposition, and had reached Nashville, when a relapse of his disease prostrated his vital powers. He died December 15, 1884.

Mr. Blair's frank, affectionate, and manly nature had endeared him to his comrades; his conscientious and efficient discharge of duty won for him the respect and regard of the older officers with whom he was associated. His ambition was a lofty one; it was not so much to achieve as to deserve success. Deep religious conviction was the guiding force of his whole being, and the very flower and crown of his stainless life. Though lost to us, we have the comforting assurance that he has entered upon higher activities, sustained by an unfaltering trust and cherishing an immortal hope.

# PROGRESS SKETCHES.



# ILLUSTRATIONS.

# National Oceanic and Atmospheric Administration

## Annual Report of the Superintendent of the Coast Survey

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