15

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REPORT

OF

THE SUPERINTENDENT

OF THE

COAST SURVEY,

SHOWING

THE PROGRESS OF THE SURVEY

DURING

THE YEAR 1856.

WASHINGTON:
A. O. P. NICHOLSON, PRINTER.
1856.

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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LETTER

OF THE

SECRETARY OF THE TREASURY,

COMMUNICATING

The Report of the Superintendent of the Coast Survey, showing the progress of that work during the year ending November 1, 1856.

DECEMBER 23, 1856.—Read.

DECEMBER 30, 1856.—*Resolved*, That 10,000 copies of the letter of the Secretary of the Treasury, communicating the report of the Superintendent of the Coast Survey for the year 1856, in addition to the usual number, be printed—five thousand for the use of the Senate, and the remainder for distribution by the Coast Survey Office; and that the same be printed and bound with the plates in quarto form, and that the printing of said plates shall be done to the satisfaction of the Superintendent of the Coast Survey.

TREASURY DEPARTMENT,
December 22, 1856.

SIR: I have the honor to submit, for the information of the Senate, the report made to this Department by Professor A. D. Bache, Superintendent of the Coast Survey, showing the progress of that work during the year ending November 1, 1856, and the accompanying map, prepared at the Coast Survey Office, in accordance with the provision of an act of Congress approved March 3, 1853.

I am, very respectfully,

JAMES GUTHRIE,
Secretary of the Treasury.

Hon. JESSE D. BRIGHT,
President pro tem. of the U. S. Senate.

ABSTRACT OF CONTENTS OF REPORT.

CONTENTS OF APPENDIX.

I.—FIELD, HYDROGRAPHIC, AND OFFICE DETAILS.

A.—GENERAL LISTS OF COAST SURVEY PARTIES AND RESULTS.

B.—DISCOVERIES AND DEVELOPMENTS.

C.—NAVIGATION.

D.—OFFICE WORK.

II. SPECIAL OPERATIONS AND SCIENTIFIC DISCUSSIONS.

A.—LONGITUDES, AND ASTRONOMICAL METHODS.

B.—MAGNETIC.

C.—TIDES, TIDAL CURRENTS, AND WINDS.

III. LOCAL SURVEYS AND RESOURCES.

IV. MISCELLANEOUS SCIENTIFIC MATTERS.

V. MISCELLANEOUS CORRESPONDENCE.

VI. LIGHT-HOUSE MATTERS.

ALPHABETICAL INDEX.

A.

B.

C.

D.

E.

F.

G.

H.

I.

S.

T.

V.

W.

ERRATA

In Coast Survey Report for 1856.

Page 41: Line 25, from bottom, for *eastern* read *western.*

Page 59: Lines 8 and 7, from bottom, for 6. 8 and 8. 3 read 6. 1 and 7. 3.

Page 65: Lines 4 and 3, from bottom, for *five feet and seven-tenths* read 5. 9, and for *seven* read 6. 7.

Page 130: Table IX, 3d hour of column 5, "From small low water to large high," for 3. 0 read 3. 3.

Page 130: Table IX, 6th hour of columns 1 to 7, "Small ebb, &c.," read 0. 3, 0. 5, 0. 8, 1. 2, 1. 7, 2. 4, 3. 0.

Page 264: Line 21, from bottom, read—within a century it has increased nearly a mile, and at about the rate of one-sixteenth of a mile on the average in twelve years.

Page 169: Line 5, for "drawing B," read *drawing. B*, &c.

Page 169: Line 17, after "silver frame," insert—*the pivot holes being bushed with platinum.*

Page 169: Line 4, from below, for "chronographic recording in Bond's Chronographic Register," read—*recording on a chronographic register regulated by Bond's spring governor.*

Page 170: Line 5, for B and B′, read B′ and B″.

Page 170: Line 6, for "by intervening thin plates of ivory (not represented in the figure,") read—*by an intervening plate of ivory.*

Page 170: Line 7, for B and B′, read B′ and B″.

Page 170: Line 11, from below, after "pendulums," insert—*the device of Mr. Kerrison, of Philadelphia.*

Page 170: Line 15, for *slips*, read *drops.*

Page 170: Line 19, *dele* "is of the same diameter as A′ and"

Page 170: Line 21, from below, after "register," insert—*of which the regulator was.*

Page 170: Line 24, for *slips*, read *drops.*

Page 170: Line 25, for B read B′.

In Coast Survey Report for 1855.

Pages 138–140: Increase all longitudes under heading *Winyah bay*, by 3′ 56″. 7. The correction does not affect azimuths or distances.

In Coast Survey Report for 1853.

Page 132°: Line 5, from bottom, in column of 50″, for 1266. 4 read 1276. 4.

Page 137°: Line 5, from bottom, in column of 50″, for 1237. 5 read 1237. 2.

REPORT.

COAST SURVEY OFFICE, WASHINGTON, D. C.,
December 1, 1856.

SIR: In compliance with the law and the regulations of the Treasury Department, I have the honor to submit my report of the progress of the Coast Survey for the past year. The report is brought up to the first of November in every case where the operations permit.

The survey has been carried on during the year in all the States and Territories of the Atlantic, Gulf of Mexico, and Pacific coasts, where it is not essentially completed.

The report is divided into three parts: the introduction, the description of operations, and the appendix.

I. The introduction contains a general notice of the progress and operations of the survey, with references to the more detailed descriptions contained in the second part of the report, or in the appendix, and the estimated progress of the next fiscal year, with estimates of the means necessary to secure that progress.

II. The second part of the report gives a detailed account of the field and office work, arranged under the head of geographical sections, numbered from one to eleven, and subdivided according to the several classes of operations as conducted by the different officers of the survey. The statistics of each operation, as reported, are given in this part of the report. Each section constitutes a chapter, as it were, and commences with a very general notice of the work detailed in the chapter.

III. The appendix is subdivided into the following heads: 1. *Field, hydrographic, and office details.* Under this head are general lists showing the distribution of the parties in the surveys of the present year; the names of officers of the army and navy attached to the work; the results of the survey as shown by the information communicated; the statistics of work; the capes, headlands, harbors, &c., examined on the Western Coast; the developments and discoveries, with special reports communicating those made within the year; tables bearing upon the resources for navigation on the coasts of the United States; and reports upon the work executed in the several divisions of the office; together with lists of the coast survey maps and charts published or in course of preparation. 2. *Special operations and discussions* relating to the determination of longitudes, the magnetic elements, tides, tidal currents, and winds. 3. *Local surveys,* features of country, and the resources for development at different points on the coasts of the United States, as coming within the notice generally of parties employed in the several localities. 4. *Miscellaneous scientific matters,* relative to methods and implements applicable in the work, analyses, memoirs on special subjects, &c. 5. *Miscellaneous correspondence having* incidental connexion with officers and parties engaged during the year. 6. *Light-house matters.*

The report is preceded by a table of contents and an alphabetical index.

GEOGRAPHICAL SECTIONS.

The limits of the geographical sections into which, for convenience, the survey is divided, and which, from the data before me when the division was made, were supposed to contain about equal amounts of shore-line, are as follows:

SECTION I. From Passamaquoddy bay to Point Judith, including the coast of the States of Maine, New Hampshire, Massachusetts, and Rhode Island.

SECTION II. From Point Judith to Cape Henlopen, including the coast of Connecticut, New York, New Jersey, Pennsylvania, and part of Delaware.

SECTION III. From Cape Henlopen to Cape Henry, including the coast of part of Delaware, Maryland, and part of Virginia.

SECTION IV. From Cape Henry to Cape Fear, including part of Virginia and North Carolina.

SECTION V. From Cape Fear to the St. Mary's river, including part of North Carolina, South Carolina, and Georgia.

SECTION VI. From the St. Mary's river to St. Joseph's bay, coast of Florida peninsula, and including the Florida reefs and keys.

SECTION VII. From St. Joseph's bay to Mobile bay, including part of the coast of Florida and Alabama.

SECTION VIII. From Mobile bay to Vermilion bay, including the coast of Mississippi and part of Louisiana.

SECTION IX. From Vermilion bay to the boundary, including part of the coast of Louisiana and that of Texas.

SECTION X. Coast of California, from the southern boundary to the forty-second parallel of north latitude.

SECTION XI. Coast of Oregon and Washington Territories.

To each section corresponds a plate showing the limits and the progress of the different operations, and lettered from A onwards.

GENERAL STATEMENT OF PROGRESS.

It is not easy to give an intelligible description of the progress of the survey in a very condensed form; but by following such a general sketch of the coast as that given on the map of lines of magnetic declination, (Sketch No. 61,) so as to seize the general limits mentioned, the annexed description may serve to furnish a general view of the work executed. It is more than half completed on the Atlantic and Gulf coast, and the present progress is at a much more considerable rate than the past. I estimate that from ten to twelve years will find the field-work essentially completed in all the sections just mentioned but two, and those only recently begun, provided that no unforeseen hindrance occurs to the operations now planned as in turn to be executed. The great increase of prices of every sort has, of course, retarded the survey materially, the appropriation not keeping pace with it.

Referring to the sketch of the coast already alluded to, the triangulation extends unbroken from Mt. Desert, *Maine*, seventy-four miles from the boundary (one link being, however, only connected in a preliminary way) to within twenty-seven miles of New Inlet, Cape Fear, *North Carolina*, or from latitude 44° 21′ N. to latitude 33° 31′, affording the basis upon which the other operations rest. South of this it includes Cape Fear entrance and along the coast to Lockwood's Folly, *North Carolina;* Georgetown entrance, Winyah bay, and Georgetown harbor, *South Carolina;* from Long island, north of Charleston, to the Hunting islands on the south side of St. Helena sound; from Calibogue sound to the south side of Tybee entrance, *Georgia;* and up the Savannah river to the head of Argyle island; Sapelo entrance, Doboy entrance, St. Simon's entrance, and up Turtle river to beyond Brunswick; St. Mary's entrance and Fernandina harbor, *Florida*, and St. Mary's river, St. John's entrance, and up the river to Jacksonville; from Virginia key, north of Cape Florida, to Key Rodriguez, and from Jacob's point (Key Vacas) to the Marquesas, west of Key West, including two-thirds of the outer keys and reefs of *Florida*, the coast of *South Florida* from the Miami to the head of the Gulf of Florida; from Homosassa bay, western coast of *Florida* peninsula, to Cedar Keys; Ocilla river entrance; St. Mark's harbor; Apalachicola harbor and part of St. George's sound; St. Andrew's harbor and sound; Pensacola harbor and part of Santa Rosa sound; Mobile bay and approaches; Mississippi sound, Lake Borgne, and part of Lake Pontchartrain, connecting the cities of Mobile and New Orleans; part of Chandeleur sound; Isle Dernière and Caillou bay, Atchafalaya bay, and part of Côte Blanche and Vermilion bays, Galveston entrance, lower and upper bays, and West bay; the coast of *Texas* from Galveston, to include the greater part of Matagorda bay and the entrance to the Rio Grande. On the *Western Coast* the main triangulation is complete from Sonoma mountain to south of Monterey; secondary triangulation has been made in California, near San Pedro, near Santa Barbara, and the islands, and in San Diego bay; north of San Francisco, Bodega bay, Ballenas, Humboldt, and other harbors have been surveyed; in *Oregon*, Columbia river entrance and to beyond Astoria; in Washington Territory, Shoalwater bay, Washington sound, including its islands and the Straits of Rosario and De Haro, Bellingham bay, New Dungeness harbor, Port Townshend, Duwamish bay, and Seattle harbor, Greenville harbor, Port Ludlow, Port Gamble, and Steilacoom harbor, have been surveyed.

Upon the triangulations the topography is based, following them at an interval of about one season, as a rule, and showing the details of the shore-line, capes, headlands, &c., the character of the natural and artificial features of the shore, by which a navigator would recognise it, and the communications from place to place, almost as important as the coast line itself.

The hydrography is based upon this topography, and gives the features below the water by soundings, the tides, currents, &c.

In *Maine*, some detached work has been done east of the Penobscot, near the mouth of the Kennebec, in Casco bay and Portland harbor. In *New Hampshire*, Portsmouth harbor and the approaches have been surveyed. In *Massachusetts*, Newburyport, Ipswich, and Annis Squam harbors, and the coast between them; Massachusetts bay, including Gloucester, Salem and Beverly, Marblehead, Nahant, Plymouth, and Wellfleet harbors; Stellwagen's Bank and the Minot Rocks, Cape Cod shore, and Nantucket, broad off to George's Bank, is nearly done; Monomoy and Nantucket shoals, Nantucket and the Vineyard sounds, and Buzzard's bay. In *Rhode Island*, *Connecticut*, *New York*, and *New Jersey*, Narragansett entrances, Long Island sound, Hell Gate, New York bay and harbor, and part of the Hudson; the bay of the five States, from Nantucket shoals to Delaware bay. In *New Jersey*, *Delaware*, *Pennsylvania*, and *Maryland*, Delaware bay and river to Trenton, and the seacoast of Delaware and Maryland.

In *Maryland* and *Virginia*, Chesapeake bay and its dependencies, and most of its rivers. The coast of *North Carolina* from Hatteras to south of Ocracoke, Hatteras and Ocracoke inlets, Beaufort, the Cape Fear to Wilmington, Hatteras, Cape Lookout and Cape Fear shoals. In *South Carolina*, Winyah bay and Georgetown harbor, Cape Roman shoals, Bull's bay, harbor of refuge to the north of Charleston and Edisto to the south. Rattlesnake shoals, Charleston harbor, the seacoast from Charleston to Tybee entrance, St. Helena sound and South Edisto entrance, Martin's Industry shoal, Port Royal entrance and Beaufort river. In *Georgia*, Tybee entrance and the Savannah river to the head of Argyle island, Romerly marshes, Doboy inlet, and Altamaha river to Darien, St. Andrew's entrance, St. Simon's entrance, Turtle river, and Brunswick harbor; St. Mary's, or Cumberland entrance, and St. Mary's river. In *Florida*, Fernandina harbor and St. John's river to Jacksonville, Cañaveral shoals, the Florida reef, from its beginning near Cape Florida to Key Rodriguez, and from Key Vacas to its termination, Key West harbor and approaches, Key Biscayne bay, Legaré anchorage, Bahia Honda harbor, Tampa bay, Waccasassa bay and the coast, and including Cedar Keys harbor; Ocilla river entrance, St. Mark's and Apalachicola harbors and approaches, St. Andrew's bay, Pensacola harbor, and part of the bay. In *Alabama*, *Mississippi*, and *Louisiana*, Mobile bay and entrance and approaches, Mississippi sound, and the Gulf coast to Pass Christian and Pearl river entrance, the outer coast to Chandeleur bay and islands, the delta of the Mississippi, Pass Fourchon, (reconnaissance,) Isle Dernière, and the entrance to Caillou bay, Atchafalaya entrance and part of Côte Blanche and Vermilion bays, Calcasieu entrance, (reconnaissance.)

In *Texas*, Sabine river entrance, (reconnaissance,) Galveston upper and lower bays, and the seacoast of Texas to the head of Matagorda bay, Aransas Pass, (reconnaissance,) and the entrance to the Rio Grande.

A general hydrographic reconnaissance has been made of the coast of *California* and *Oregon;* every harbor has been surveyed, and preliminary charts of nearly all have been published. In *Washington Territory*, a considerable portion of Washington sound, including the Straits of Rosario and the Straits of Haro, has been surveyed, Bellingham bay, New Dungeness and False Dungeness, the entrance of Admiralty inlet, Port Townshend, Steilacoom and Seattle harbors, Port Ludlow, Port Gamble, and Shoalwater bay, and charts have either been published or are in progress of engraving.

The localities surveyed on the western coast have included fourteen capes and headlands, eleven islands, thirty-one harbors and anchorages, fourteen bays, two reefs, seven straits and entrances, three rivers, and three cities; and charts or maps of the whole have generally been published when the importance of the locality justified it. Thus, of eighty-five surveys classed as just stated, of which the titles are given in Appendix No. 6, sketches or maps and charts have been published of sixty-five, and those of some others are in progress. Seventeen surveys have been added during the past year. Nearly all the more important preliminary surveys, detached from the regular progress along the coast, have been made in California and Oregon, and many in Washington Territory. The capes and headlands in many cases have been surveyed in reference to light-house purposes. There is no delay whatever in publishing these sketches, which, on the contrary, are put in hand as soon as received, so that the field-work of the season furnishes the sketches for the report. Nearly three-fifths of the harbors on the Atlantic and Gulf coast have been surveyed, and charts of them have been published. Charts of all the dangerous shoals, from Nantucket to Cape Cañaveral, have been made and published, and are included generally in the Coast Survey reports. The inlets, with perhaps ten exceptions, have been surveyed, and charts of all except those of the last year's survey have been published, and charts of those are in progress.

The electrotype process permits us, without waste, to begin a seacoast chart as soon as one season's work is done, and to add to it year by year as the work comes in. Thus it is no longer necessary to wait for the full results desirable for a complete chart before beginning to publish. In this way we have commenced the seacoast chart of New Hampshire and Massachusetts, the Nantucket shoals, the seacoast of Delaware, Maryland, and Virginia, of North Carolina from Cape Hatteras, of South Carolina and Georgia between Charleston and Savannah river, of the Florida reefs and keys; of the coast of Florida near Cedar Keys, of Mississippi sound, of Chandeleur sound, of Atchafalaya bay, and of the coast of Texas from Galveston southward.

The principle adopted is, to publish a sketch, or a preliminary chart, as soon as the data are in the office, and to follow afterwards with the finished charts. In this way charts of one hundred and twenty-two harbors, inlets, shoals, &c., have been published as the materials have been received. The progress sketches themselves are also made the vehicle of information collected out of the regular course, and deep-sea soundings made on the Atlantic and Gulf of Mexico coasts will be thus found recorded, with sections of the bottom corresponding to them.

When the importance of the locality justified it, and the regular operations could not properly be extended to special localities, reconnaissances have been made and published in advance of the regular work. In this way, there being special calls for the hydrography of Port Royal entrance and of Doboy and St. Simon's entrances, reconnaissances were made and communicated to the Department, and are now engraving. The hydrographic reconnaissance of the Western Coast was made and published within two years and a half after our acquisition of California. This has been revised and improved by additional work, and again published in its revised form. Preliminary charts of nearly every harbor on the western coast south of Puget's Sound have been already published.

No material comes into the office from parties in the field or afloat which is not at once cast into the form of maps, charts, sketches, or preliminary charts, and no hydrographic material which is not in the engraver's hands within the year after it is turned over to the archives.

The effort which was made by sending the assistant in charge of the office abroad to find engravers was quite successful in regard to those approaching near to the first class and in the second class, and will enable us, as soon as they have grown familiar with our style of work, to make the desired progress in the finished maps. There is still room for two first-class engravers, if they could be had, but such workmen are scarce even in Europe, where the governments have so long encouraged the highest style of map engraving, and where the competition from bank-note engraving which occurs in our country is not so strongly felt.

One hundred and twenty-one of the published sketches, preliminary charts, and maps are to be had of the general disbursing agent of the survey, (see Appendix No. 19,) and within the year sixty-nine have been published, including those with the report of 1855.

The total number of impressions of maps, charts, and sketches distributed from the office during the year was eleven thousand seven hundred and fifty-six, exclusive of those contained in the annual reports.

A good mode of obtaining a distinct idea of the progress of the work during the past year is to refer to the table given in the Appendix No. 1, where, under the head of each geographical section, the character of the work of each officer of the survey is stated, and its limits during the surveying season.

DISCOVERIES AND DEVELOPMENTS.

During the course of the work, discoveries or developments of greater or less value to commerce and navigation have been made, almost as matters of course, on a coast so imperfectly known as was that of the United States. The more important of these up to 1855 are collected in the Appendix No. 8, and those of the present year are given in the body of the report.

Among the developments made in the course of the hydrography of the season, most worthy of notice, is the extensive bank of comparatively shoal ground between George's Bank and the coast of Massachusetts, portions of which have been known to navigators, and misnamed, as if consisting of special shoals or ledges. The full description of this is given in the hydrography of Section I. The careful investigation of the newly discovered channel through Martin's Industry into Port Royal harbor is another important result. This channel has not less than twenty feet water in it, and is two miles to the southward of the old east channel, and two miles and three-quarters to the northward and eastward of the main, or south channel. (Appendix No. 15.) The sounding out of a bar off San Diego harbor, and the determination of the limits of Cortez shoal, off Santa Barbara, rank also with the foregoing. A complete list of developments and discoveries is annexed, and in Appendix No. 8 the list is brought up to 1855, inclusive.

1. Determination of the position of a sunken rock, on which the steamer Daniel Webster struck, in Casco bay, on the evening of the 13th of October.

2. Development of a reef extending between Minot's and Scituate light.

3. A sunken rock, with only six feet on it at low water, off Webster's flag-staff, Massachusetts bay.

4. A dangerous rock near Saquish Head, entrance to Plymouth harbor.

5. Three rocks determined in position, partly bare at low water, off Manomet Point, Massachusetts bay.

6. Determination of a very dangerous rock, off Indian Hill, and four miles southward of Manomet Point, Massachusetts bay, with as little as six feet water on it.

7. Non-existence determined of "Clark's Bank" and "Crab Ledge," laid down on certain charts as distinct from an immense shoal ground off Cape Cod peninsula.

8. Discovery of two shoal spots with twelve and thirteen feet water, eastward from Great and Little Round shoals, Nantucket sound.

9. Determination of two shoal spots near the northern extremity of Davis' Bank, with fourteen and eighteen feet water.

10. Further development of Edwards' shoal, three-fourths of a mile from the southern Cross Rip, Nantucket sound.

11. Discovery of shoal sand ridges northward of Great Point light, Nantucket sound.

12. Important changes in geographical feature at the southeastern end of Martha's Vineyard, Muskeget channel.

13. Determination of changes occurring in New York harbor.

14. Investigation of the cause of changes at Sandy Hook.

15. The tides of Hudson river.

16. Minute development of the changes affecting the entrance to North Edisto river, South Carolina.

17. Discovery of a new channel between Martin's Industry (shoal) and southeast breakers, off Port Royal entrance, South Carolina.

18. Directions for entering the harbor from Crystal river offing, western coast of Florida peninsula.

19. Co-tidal lines of the Gulf of Mexico.

20. On the effect of wind in disturbing the tides of the Gulf of Mexico.

21. Development of a bar at the entrance to San Diego bay, California.

22. Determination of a point of rock on Cortez shoal, and subsequent complete hydrographic survey of the shoal.

23. Investigation of currents of Santa Barbara channel.

24. Further development of the extent of Commision Rock, San Pablo bay.

Most of the items in the foregoing list speak for themselves; a few passing remarks on others seem to be desirable.

The general developments in New York harbor will be more properly stated when the comparative map, now in progress, is completed. In this, the surveys of 1836 and 1856 will be carefully compared, and the interesting changes which were briefly referred to in my report of last year will be fully brought out. Some of the special matters, however, will be treated at once.

It is a well established fact, and a most important one to the future of New York harbor, that Sandy Hook continually increases to the northward, narrowing the main ship-channel entrance.

To ascertain the causes of this, so as, if necessary, to control the action, a series of observations were made during the past year by request of the Commissioners on Harbor Encroachments of New York, and at their expense. The results are of a definite sort, of great value, and give every encouragement in reference to the power to control this growth of the Hook, should it become necessary. A general statement of the observations, and of their results, will be found in the Appendices Nos. 38 and 39. The deposit is caused by a slowly moving northwardly current, on both sides of the Hook, running on the outer side more than seven hours out of the twelve, and on the inner, eleven hours out of the twelve, during both the ebb and flood tides, and meeting at the point of the Hook.

A comparative map of the upper part of the Hudson is also in progress, representing the surveys of the civil and military engineers in previous years, and the present state of the river bed, as compared with that in 1853 from these data.

A knowledge of the progress of the tide-wave up the Hudson river is of special importance in the determination of the shore-lines of the river, near its mouth in New York bay, and near the head of the tide, above Albany. At the request of the Commissioners on Harbor Encroachments, and mainly at their expense, an elaborate series of tidal observations was made, extending through nearly a lunation, and embracing nine stations, between Governor's island, in New York harbor, and Greenbush, opposite Albany. At the two terminal stations, self-registering gauges were employed, and the harbor station is the one where a permanent self-registering tide-gauge has been placed and observed for several years. The results of these observations are undergoing discussion in the tidal division. (Appendix No. 40.)

In connexion with the tidal and current observations in New York bay and harbor, valuable observations have been made of the progress of the tide-wave and of the tidal currents, in the passage from Raritan bay to Newark bay, Staten Island sound, or Arthur Kill, and from New York bay to Newark bay, through Kill van Kull. These contain the clue to the complicated action of the currents which causes the bars in the lower part of Newark bay, or the communication between Arthur Kill and Kill van Kull. A general statement of the observations made will be found in Appendix No. 39.

In this same connection full observations were made of the set and drift of the currents in the docks, slips, and basins of New York and the adjoining cities, with a view to questions relating to their mode of construction, and other points of interest to the harbor commissioners, at whose request the observations generally were made. They include quite an elaborate series of current observations in and near the Atlantic dock, and in Buttermilk channel.

The results of the determination of the specific gravity, and amount of saline matter in the water taken from different parts of New York harbor, and at different depths, by Professor Wolcott Gibbs, of the Free Academy, will be found in Appendix No. 63. The temperatures at and below the surface of the water were taken, in connection with these specimens, to ascertain the variation in the point of maximum density from the fresh water of the river to the salt water of the ocean; but either the temperatures of the strata were the same from the surface to the bottom, at the different stations, leaving irregular variations out of consideration, or the instruments used (Saxton's metallic thermometers) were not delicate enough to indicate the differences.

The change in depth developed at North Edisto entrance (Appendix No. 14) has required but a small alteration in the sailing directions and in the chart, a new edition of which has been issued.

The importance of the discovery made last year of the red sand marking the entrance to San Francisco bay is enforced in letters from the commanders of steamers on the Western Coast. (Appendix No. 16.)

Details relating to a portion of the matters in the preceding list will be found in the Appendix, between Nos. 9 and 15.

OFFICE-WORK, MAPS, AND CHARTS.

There are three classes of finished maps or charts. The first extend along the coast, embracing the shore-line and interior to the nearest main road, and the hydrography for some fourteen miles from the shore. These are called in-shore or coast maps and charts, and the scale of $\frac{1}{80000}$ has been adopted for them. The second are the general coast charts, or off-shore charts, on the scale of $\frac{1}{400000}$, tracing the shore-line of the coast and its general topographical features so as to be recognized by the navigator, but omitting minute details, and giving the soundings to at least the depth of 120 fathoms, and selected in-shore soundings, so as to present a general idea of the bottom. The third are the charts of harbors, anchorages, and the like, on various scales from $\frac{1}{5000}$ to $\frac{1}{30000}$, presenting in minute detail the soundings, tides, and currents of the separate harbors, the outline of the shores, the topography of the landings and country adjacent to the shore, and inward to the nearest land communication.

The arrangements of these classes of charts are of course the subject of much study, and embrace various principles and details. The rule was early adopted to arrange them in such a way that the same atlas would contain them all; a rule which, if departed from in certain cases, has been with the greatest reluctance, and only from overruling considerations.

A special study is made of each of these classes, and projects are from time to time presented to the Superintendent for examination.

As early as the development of the work would admit, I studied in connected form the first and second classes of these maps. The inaccuracy of existing maps rendered this only a preliminary study; and from time to time, as our materials have been collected from the Coast Survey itself, the study has been resumed. During the past year, I availed myself of the special aptitude of one of the draughtsmen (Mr. Boschke) for this work, to have the whole subject resumed in a connected form, and in this shape it is now in progress. The fertile mind of Captain A. A. Gibson was also, during the last year of his connection with the survey, turned specially into this channel, and many excellent projects were produced by him for prospective execution.

Besides this classification of maps according to the kind and locality, we recognize another founded on the style of execution appropriate to the map or chart. The lowest class are those known as sketches, of which there are two kinds: progress sketches, showing from year to year the advance of the work; and sketches of parts of the coast, either connected portions or detached capes, headlands, rocks, shoals, channels, anchorages, harbors, bays, sounds, and rivers. The progress sketches are added to year by year, as the new work comes in, and show by special signs, explained upon the face of the plates, the work done of each kind, in each year. These plates at the beginning of the survey in the several sections were small, and the additions required to their surface have been made from time to time by the electrotype process, or new plates have been engraved as the old ones became too imperfect for use. During the past year the survey has been considered as sufficiently advanced in all sections to revise the whole of the progress sketches, and to make new ones on uniform scales and with details more in harmony with each other. The sketches of particular localities are based upon reconnaissances or upon regular surveys. They present the details of the hydrography with generally a true outline of the shore. These for the most part are engraved by the apprentices in the office of the Coast Survey, and serve as subjects for practice. In my annual reports, lithographic transfers of these sketches are published. They enable us to present at once the results of the work, without waiting for entire completeness, and thus to keep the information published close to the results obtained. We strive to have no important result in the archives of the Survey which is not in immediate progress of publication. Thus, as a rule, a year is not allowed to elapse between the making of a survey and its publication in some shape useful to the mariner.

The next class of charts in regard to finish are called preliminary charts. They also enable us to keep up with the surveying operations in the field and afloat. Thus the seacoast of Delaware, Maryland, and Virginia was drawn and engraved as each season's work was turned in by the hydrographic officer, and by the electrotype process a new plate was made large enough to retain the old and to receive the new work. The plan thus pursued is now reduced to a system. Projects for preliminary charts were examined and approved, and the charts put in the hands of the draughtsmen and engravers so as to bring up the arrears of this kind of work, and projects were made so as to keep up with the new. For the principal charts of this class, the scale of $\frac{1}{200000}$ has been adopted. For the harbor charts of this class, various scales must, of course, be used, suited to different localities. Sometimes a preliminary chart has embraced the shore-line and soundings of a map intended to be of the highest or finished class; but this is rare, and defeats in a degree the object of this work, which belongs essentially to engravers of the second and third class.

The finished charts are those requiring the work of first-class engravers, so difficult to be procured in any part of the world. To make them to the greatest advantage, the work should be in a very forward condition, as any variations, from a supposed extent or arrangement of the chart, is destructive. This of itself involves delay, and would keep the finished charts at a certain distance behind the work in the field and afloat. But this is not the greatest obstacle. The work is very slowly executed, and the engravers who are capable of it are few in number. We had but four first-class engravers in the office at the beginning of this year, notwithstanding the great efforts made at home and, by correspondence, abroad to add to their numbers.

In the introduction to my report of last year, (1855, p. 21,) I stated the urgent necessity for additional first-class map engravers in our office, to keep pace in the publication of finished maps with the field-work, and gave the history of our attempts to procure such at home and abroad. I also gave the views of Captain Benham, of the corps of engineers, then assistant in charge of the Coast Survey office and my own, addressed to the Treasury Department, as to the mode of supplying this deficiency. (Appendix Nos. 37 and 38, 1855.) With the sanction of the Hon. Secretary of the Treasury, Captain Benham received instructions to visit the principal engraving establishments abroad, and, carefully avoiding all interference with the government offices in reference to the matter in hand, to obtain such engravers as were competent to our work and willing to undertake it, with the consent of the officers by whom they were employed. This duty was accomplished by Captain Benham, with his usual zeal and ability, and we have gained by it four first-class topographical engravers and two second-class engravers, whose style of work we expect, by training, to bring to that of our office, and who will then become available for the execution of our finished maps. Much incidental information was obtained by Captain Benham in relation to this and other subjects connected with the Coast Survey work, and opportunity was taken to promote the exchanges of maps and documents with the officers of foreign surveys. This has already resulted in the receipt of some beautiful and valuable government works, which we could hardly have procured in any other way. The details will be found referred to under the head of "office-work."

The list of maps, charts, and sketches accompanying the report of the chief of the drawing division (Appendix No. 19) contains the titles of ninety-five drawings, which have been in hand since the close of the preceding year. Of these, forty-two commenced this season have been completed, with twenty-nine begun previously, and twenty-four are yet in progress. Twenty-nine of the entire number are finished maps, ten preliminary charts, and fifty-six sketches and diagrams.

In the engraving division four first-class maps have been completed during the year, and fifteen have been in progress. Of these last, eleven were commenced in former years, and four in the present year. Twenty-eight second-class maps or charts and sketches have been completed during the year, of which eighteen were begun in the present year. Eleven of the same class, commenced within the year, are in progress. Nine diagrams have been completed, and two are in progress. This gives a total of forty-one plates completed, and of twenty-eight in progress, or of sixty-nine engraved or engraving within the year ending November 1, 1856. Of the forty-one plates completed this year, six were included in last year's list, being at its date nearly completed. The complete list, giving the titles of the maps and charts, will be found in Appendix No. 19. The list of maps, charts, and sketches up to the present date, as given in that appendix, includes two hundred and sixty-one plates. Of these, forty-eight are of first-class or finished maps, and twenty-five of progress sketches.

The following is a list of the preliminary charts and sketches accompanying this report:

1.—A. Progress sketch, Section I, (primary triangulation.)
2.—A *bis*. Progress sketch, Section I, (secondary triangulation, topography and hydrography.)
3.— Seacoast of Massachusetts, No. 1, (preliminary chart.)
4.— Monomoy shoals, additions.
5.—B. Progress sketch, Section II.
6.— Hudson river, from Albany to New Baltimore, (comparative chart.)
7.—C. Progress sketch, Section III.
8.— Patapsco river.
9.— Rappahannock river, No. 1. Fredericksburg to Moss' Neck.
10.— Rappahannock river, No. 2. Moss' Neck to Port Royal, Virginia.
11.— Rappahannock river, No. 3, (preliminary chart.) Port Royal to Saunders' wharf.
12.— Rappahannock river, No. 4, (preliminary chart.) Saunders' wharf to Occupation creek.
13.—D. Progress sketch, Section IV.
14.— Seacoast of North Carolina, from Hatteras to Ocracoke, (preliminary chart.)
15.— Cape Fear river, upper sheet. Federal Point to Wilmington, N. C.
16.— Diagrams showing effect of wind upon high and low water in Albemarle sound.

An improvement in the use of electrotype plates has been made by the fertile invention of Mr. Mathiot, namely: to print from thin plates, say not thicker than ordinary drawing or map printing paper, stretched upon a smooth plate of copper, zinc, or iron, merely as a backing. The details of several experiments are given in the report of Mr. Mathiot in the Appendix, No. 62. The saving in time and expense by this process, and the economy of space and weight, and in preserving the plates, are obvious. It has passed into one of the regular applications of the electrotype process. Progress has been made by Mr. Mathiot in the process of actino engraving, noticed in my last report.

The information given under authority from the Treasury Department, from the archives, consisting of data for latitude and longitude, tracings, or copies of maps, charts, and sketches, is stated in the Appendix, No. 5. Eighty-six applications have been answered, of which eleven were from departments of the government, sixteen from officers of the United States or of State governments, five from municipal officers or local associations, seven from members of Congress, and forty-seven from individuals. Besides these, copies of maps, charts, and sketches, and proof-sheets of maps have been sent on application, and by authority of the Department. The list shows how widely this information is diffused over the country, and that the demand extends to surveys of all portions of the coast.

Calls are frequently made by committees of Congress, boards of underwriters, and others connected with the legislation, commerce and navigation, or improvements of the country, for information in regard to the depths of water which can be carried across various bars, into anchorages, into different ports and harbors, up rivers, and the like. To meet these I have had compiled in the Office of the Coast Survey a list of this sort, chiefly from the data of the survey, and this has been revised by two of the most accomplished of the hydrographic assistants, and is presented in the Appendix, No. 18. The tidal data for it have been revised by the assistant in charge of that division. The title of the list and the headings of different columns show explicitly what is intended by the figures.

The sailing directions referred to in my report of last year have undergone a revision by the same hydrographic officer who prepared the list just referred to, and are nearly in readiness for printing with the records and results.

LONGITUDES BY TELEGRAPH.

The operations for telegraphic difference of longitude have made good progress. They consisted in verifying the difference of longitude of Wilmington, North Carolina, and Columbia, South Carolina, which had previously been obtained through Raleigh, North Carolina, by the direct line along the Wilmington and Manchester railroad; in connecting Macon, Georgia, with Montgomery, Alabama; in preparing the longitude station at Mobile, and in selecting the site for the station at New Orleans. The report of Dr. Gould will be found in the Appendix, No. 20, and with it a valuable list of positions of circumpolar stars, revised and improved from the list given last year.

In reply to various inquiries in reference to the details of our methods for difference of longitudes, the general facts in regard to which have been stated in my reports yearly given, I requested Assistant George W. Dean to draw up an account from the actual working during the past season, and have placed it in the Appendix, No. 21. During the last spring I visited the telegraphic parties, and had reason to approve highly of their zeal, industry, and success in the work. We expect that our determinations this year will include New Orleans. Dr. Gould is engaged in preparing the materials for a volume of the records and results relating to telegraphic difference of longitude.

While on this subject I feel compelled to observe that the recent methods recommended by

M. Le Verrier for observing differences of longitude by the telegraphic methods, are simply those which have been in use in the Coast Survey for some six years.

LONGITUDES BY CHRONOMETERS.

The chronometer expedition of 1855, as stated in my last report, was again placed under the charge of Professor W. C. Bond, Director of the Harvard observatory. The number of chronometers employed was fifty-two, and of voyages made across the Atlantic, six—three out and three back. The points in which this expedition differed from the previous ones were the following:

1. The observations of transits for clock error, and the comparisons of the chronometers employed in the reductions were made exclusively by the electro-magnetic method.
2. The appropriate means were employed to secure an entire elimination of personal equation.
3. In the general conduct of the expedition, attention was specially directed to the effect upon the resulting longitudes of the temperatures to which the chronometers were subjected.

The results have been discussed as before by Professor George P. Bond, (see his report, Appendix No. 23,) and the methods of discussion were in general the same as in the cases of former expeditions of 1849, 1850, and 1851. The difference in the instruments employed seems to be the only outstanding one of any considerable importance.

A thermometric chronometer was made expressly for the expedition, the uncompensated balance of which gave a change of rate by temperature which followed the changes of temperature themselves. This instrument proved more effective in giving the mean changes of temperature than the use of the ordinary thermometer, which was also attempted.

The chronometers were exposed to varying temperatures, and the effect upon them carefully studied, so as to apply an empirical correction for it. This correction proved to be of the form assigned to it in the previous reports. The care taken to prevent the exposure of the chronometers to any considerable variations of temperature during the voyages, was such as to confine the mean temperatures within the small limit of 58°.4 Fahrenheit and 67°.3.

The final longitude for these voyages is reported by Mr. George P. Bond as: Cambridge, west of Greenwich, 4*h.* 44*m.* 31.89*s.*, with a probable error of 0.19*s.*; or from Liverpool 4*h.* 32*m.* 31.84*s.*, with a probable error of 0.19*s.*

The results for the eastern and western voyages, which, in previous expeditions, were discrepant, agree within the probable error of the present results.

After a somewhat careful examination of this and former results, I have come to the conclusion that the previous expeditions must be considered as preparatory to this, their chief use being in pointing out the errors to which the methods were liable, and in suggesting the proper modes of eliminating them. The full particulars of these observations are in preparation, by George P. Bond, Esq., for publication with the records and results of the Coast Survey. If there were not so fair a prospect of a telegraphic connection with Europe, it might be desirable to continue these researches by the transportation of chronometers. When we consider that the recent determinations of the difference of longitude between London and Paris by the telegraphic method indicate an error in the previously accepted results of one second of time, we are not to be surprised that there should be a difficulty in reducing our uncertainty between Greenwich and Cambridge to a less quantity.

LONGITUDES BY OCCULTATIONS AND MOON CULMINATIONS.

Director W. C. Bond has made the usual report of observations of occultations of stars by the moon, and of culminations of the moon and of moon culminating stars during the past year; and also of transits of bright points on the moon's surface, for further trying the value of this mode of observation. (Appendix No. 22.) Assistant George Davidson has also continued for the

Western Coast, observations of the occultations of α Scorpii, and of the planet Mars, in April and May, 1856. (Appendix No. 26.)

An interesting report by Doctor C. H. F. Peters, in continuation of the method of observation of lunar spots, instead of the edge of the moon's disk, with moon culminating stars, is contained in the Appendix No. 25. Doctor Peters shows that the probable error of one observation of the transit of a suitable selected lunar spot over the wire of a transit instrument, is as small as that of a star within the limits of the zodiac. A notice is given of corresponding observations at Cloverden and Harvard observatories, and the necessity for more direct comparisons with similar instruments is clearly shown. Doctor Peters also discusses the mathematical theory of the transits of moon culminating stars and of lunar spots.

The numerous errors in the printing of Professor Peirce's article on the determination of longitudes by occultations of the Pleiades, in the Appendix to my report of last year, render its reprint with this report desirable, and I have accordingly placed it in the Appendix, No. 24.

MAGNETIC OBSERVATIONS AND RESULTS.

In pursuance of a plan which I adopted soon after taking charge of the Coast Survey, of determining the magnetic elements at the primary stations, in all the principal ports, and at certain secondary stations along the coast, numerous observations of the magnetic variation, (declination,) dip, (inclination,) and intensity, have been made. These have, from time to time, been discussed under my direction, chiefly to ascertain where apparent discrepancies existed, so that the observations might be repeated, or others be made at neighboring localities. The number of these results and their distribution is now such as to warrant a preliminary discussion of them, with the further view to determine the system of lines of equal variation, dip, and horizontal intensity. This is done in the memoir given in the Appendix No. 28, which is accompanied by a map showing the lines deduced, and by a diagram comparing lines derived from Gauss's elaborate mathematical theory, with those on Barlow's map of 1833. To this memoir is appended the list of stations, with their latitudes and longitudes, their magnetic constants, and the character of the geology of the region. This list has, at my request, been kindly revised by Professor James Hall, in reference to the geological notes.

Observations of great value in this discussion were derived from other sources than the Coast Survey, which are fully acknowledged in the article in the Appendix, and for the use of which their authors have our best thanks.

The results of observations made during the season for the determination of magnetic elements at a number of stations between Delaware bay and Cape Henry are given in Appendix No. 30.

As it is important to reduce the magnetic results for our charts to the date of publication, Mr. Schott has collected the observations of variation (declination) and of dip, on the Western coast, and has deduced the most probable value of their changes in the reports which will be given in the Appendix Nos. 31 and 33.

In the eighteenth century the eastwardly variation on the Western coast increased at the rate of about five minutes yearly; on the northern part of the coast, about one fourth more rapidly; and on the southern, one fourth less. While this was the average annual rate of increase, the actual rate was a diminishing one, and this diminishing rate continues during the present century, and indicates that the variation will in the course of it reach a maximum east. The average increase between 1850 and 1860 is about a minute a year.

The system of lines of equal declination moves slowly to the southward on both the Atlantic and Pacific coasts—more slowly in the southern, and less slowly in the northern portions of the coast.

The observations from which the secular change of the magnetic dip (or inclination) is deduced are quite scanty. They indicate, however, that since 1836 the dip has been on the increase at a rate of about two minutes a year.

Mr. Schott has also collected and discussed the observations for magnetic dip made in and near the United States, and has deduced interesting conclusions in regard to the secular variation of the dip and to the period of least dip, which occurred quite recently.

The results are confined to the limits of 38° and 44° of north latitude, there being too few observations in the southern part of the United States to permit safe inferences from them.

The element of magnetic dip, though less important, practically, than that of declination, is of value in navigation in certain latitudes, and from its connection, through Gauss' investigations, with the declination and intensity, it assumes a high degree of importance.

While the declination observations on this coast go back to the seventeenth century, the dip has only been accurately observed for twenty-three years, for the earliest observations (made in 1782) were, from the imperfection of the instruments, of little use. During this period the dip has decreased, reached a minimum, and begun again to increase; so that this has been a highly interesting period for observation. The lines of equal dip have been deduced by Professor Loomis, with his usual ability, from the observations which had accumulated before the date of his paper. Mr. Schott's discussion includes additional results, and compares one hundred and sixty observations made at ten different stations between Toronto on the north, and Baltimore on the south. The same modes of discussion were adopted as in Mr. Schott's former report, and the results at each station separately discussed, and the computed results compared in tables with the observed. The average probable error of the result at any one station is about one minute and six-tenths of dip, and the time of minimum dip is ascertained to within about two years and seven-tenths. This was the year 1842 (1842.7).

Mr. Schott points out why these results do not agree with Professor Hansteen's, who had not observations enough to determine the epoch of minimum dip with accuracy. Observations on the Western Coast confirm these results for the Eastern.

TIDES, TIDAL CURRENTS, AND WINDS.

I have already noticed some of the results of the year in the observation and discussion of these subjects, under the head of developments and discoveries.

On the Atlantic coast the permanent tide-gauges at Boston, New York, Old Point Comfort, and Charleston, have been kept up chiefly with Saxton self-registering gauges, and temporary observations have been made at several points, which will be found referred to in the Appendix No. 41, and under the head of hydrography in the detailed account of progress in the various sections of the survey. No new observations, except those in the usual course of the hydrography, have been made in the Gulf of Mexico. On the Western coast the temporary observations, under the charge of Lieutenant W. P. Trowbridge, of the Corps of Engineers, have been brought to a close, and only the permanent stations at Columbia river, San Francisco, and Monterey are now kept up. (See Appendix No. 42.) For the regulation of these, and the transmission of the results, we have been indebted, since the 4th of April, when Lieutenant Trowbridge was relieved from this charge, to the voluntary and efficient aid of Lieutenant N. F. Alexander, of the Corps of Engineers, who was permitted to undertake this service, through the kindness of his immediate commanding officer, Colonel R. E. De Russy, and of the Chief Engineer. (Appendix No. 77.)

A brief notice will be found in Appendix No. 34 of the progress made in preparing prediction tables of the tides of Boston harbor, and of the methods employed for this purpose. The practical working of these will no doubt be much improved, but the present position of the work is such as to encourage to effort in the direction thus marked out.

A clear view of the progress made in computing the very interesting tidal results of Martha's Vineyard and Nantucket sounds is given in the Appendix No. 37. This work combines the result of observations directed by preliminary investigations reported in former years, and is yet incomplete. I have given much time to the subject personally, and Sub-Assistant Henry

Mitchell, under my immediate direction, has carried it forward with an ability and perseverance worthy of all commendation.

The tide tables given with my report of last year have been revised, and have received additions from the data since collected, (Appendix No. 17.) The remarks in regard to the tides of the Gulf of Mexico have also been enlarged, so as to bring the information up to the present date. The circumstances which led to the preparation of this article are fully expressed in my report of last year.

The discussion of the tides of the Gulf of Mexico (Appendix No. 35) is supplementary to those of the Atlantic and Pacific coasts given in my reports of 1854 and 1855. The type curves representing the law of the rise and fall of the tides at the various ports on the Gulf were referred to in my last report, and it is now only necessary to mention the subject for their explanation. A diagram accompanies the present report, showing the rise and fall of the tide at each port, by the aid of which the navigator may determine approximately the rise and fall of any intermediate part of the coast. The least rise and fall observed is at Brazos Santiago, and is only nine-tenths of a foot on the average; the greatest is at Cedar Keys, and it is two feet and a half on the average. The observed tidal curves are decomposed into the diurnal and semi-diurnal curves, and the cotidal lines for each of these tides are drawn upon the diagram. The tide wave entering by the Straits of Florida is followed across to the mouth of the Mississippi, passing laterally from this line to the western coast of the peninsula of Florida, and to the southern coast of Florida, Alabama, and Mississippi, also into the bay between the Southwest Pass of the Mississippi and the Rio Grande, in such a direction that it arrives later at Galveston than at the points north and south or east and west from it. The differences in the motion of the semi-diurnal and diurnal waves are pointed out in the paper. This has required much laborious and intricate discussion, and the present results are only approximations.

An interesting report by Mr. Pourtales on the effect of winds in varying the level of the water of Albemarle sound is given in the Appendix No. 43. When the hydrography of this sound was commenced, I directed continuous observations to ascertain if its level was affected by the ocean tides. It was readily found that such was not the case; and from a discussion of the tidal observations at the entrance to Pasquotank river, made under my direction by Lieutenant (now Commander) Jenkins, United States Navy, the principal facts of the case were made out for the published chart of Pasquotank. At my request, Mr. Pourtales has resumed the subject, and has given the results of his discussion in the report just referred to.

A similar discussion of the effect of the wind in raising the tides in Cat Island harbor, Louisiana, was made some years since, under my immediate direction, by Assistant George W. Dean, and is now placed in the Appendix No. 45. The general conclusions are the same in the two cases, with differences in the numerical details which are of interest and value.

Observations were conducted some years since in connection with those of the tides at Key West, Fort Morgan, Alabama, and Galveston, and a study of the winds of the Gulf coast made for purposes of navigation, and as determining the working seasons of the survey. The mode of reducing them, and determining the volume of wind blowing from a given point, is stated in the Appendix No. 44, and the arrangement of the diagrams is also explained. The diagrams render generalization very easy and safe, and express in a simple form the facts which are very difficult to follow when stated in words.

The paper in the Appendix No. 44 refers, first, to the prevailing winds for the year; second, to those of the several months and seasons, and at the different places; third, the changes in quality with the season; and fourth, to the variation in duration, from one season to another, of winds from nearly the same quarter.

SPECIAL SURVEYS AND LOCAL RESOURCES.

The account of the special surveys of New York bay and harbor and the environs, for the Commissioners on Harbor Encroachments, occupies so large a portion of the notice of operations in Section II of the coast, that it is not necessary, in this part of my report, to do more than refer generally to the chapter. The same may be said of the survey of the upper part of the Hudson, near Albany.

The progress made in the special surveys of the Florida keys and coast, and their marking for the Land Office, under the law of March 3, 1853, is stated in detail in Appendix No. 52, and copies of the topographical maps have been forwarded to the Commissioner. The sheets, as connected with the general work in Section VI, are shown upon Progress Sketch No. 26.

The survey of the islands on the Western coast, off the Santa Barbara channel, for the Land Office, under the law of August 31, 1852, has been continued, and the parties have made better progress than heretofore in this difficult work. The triangulation of Santa Cruz island has been completed, and will soon be connected with that of the main; and the topographical work of Anacapa island, part of Santa Cruz, and of the main shore adjacent, has been done. Provision has been made for the rapid extension of this work as soon as the season opens again.

The survey of the Rappahannock and James rivers, commenced for the Engineer Department, has been continued in connection with the regular operations of the survey, and the progress is stated under Section III. The operations on the St. John's river, commenced for the same department, have been completed, as stated under Section VI, and in the Appendix No. 51.

Interesting local notices will be found in the Appendix, relating to different harbors and parts of the coast: as of Brunswick harbor, by Lieutenant Commanding Trenchard, (Appendix No. 49;) of Fernandina harbor, by the same officer, (Appendix No. 50;) of St. John's river, Florida, and a second relative to the vicinity of Cedar Keys, on the western side of the peninsula, by Assistant A. M. Harrison, (Appendix Nos. 51 and 53;) of St. Marks and Apalachicola, by Sub-Assistant Spencer C. McCorkle, (Appendix No. 55;) and one from Assistant J. E. Hilgard, in reference to expedients adopted by him in prosecuting the triangulation of Mississippi sound and Lake Borgne, (Appendix No. 56.)

A communication on the resources of Washington Territory, by H. A. Goldsborough, Esquire, made through Commander Alden, is contained in Appendix No. 57.

PROJECTIONS, INSTRUMENTS, AND METHODS.

The demand for the tables for projecting maps, given in my report for 1853, having shown that a want is felt for correct information on that subject, I have caused to be prepared, under the direction of Assistant Hilgard, tables for projecting maps of large extent. These are given in Appendix No. 58, and will be found very convenient in use. They represent accurately the principle of development on which they are based, and maps constructed by them will have the least possible distortion of area. Extending the same principle to the whole surface of the sphere, a form of map results which is shown in Sketch No. 65, and which, for every purpose of physical geography, will be found very useful.

The want of a convenient apparatus for measuring subsidiary base lines in localities where the survey is commenced in advance of the primary triangulation has often been felt, and has been supplied in various ways by the assistants having charge of such work. Aided by the experience so gained, a new apparatus for the purpose has been devised by Assistant Hilgard and Mr. Joseph Saxton, in consultation with myself, which has been used on several occasions, and is found to possess, in a considerable degree, the requisite facilities for adjusting the measuring rods in position, and ascertaining their actual temperature. Appendix No. 60 gives a full description of it. The apparatus is represented in Sketch No. 64.

The description of a ten-inch theodolite, made for the survey by Mr. W. Würdemann, with the details of a complete examination of its qualities, is contained in Appendix No. 61. This was furnished by Assistant Hilgard, and is intended as a guide to other observers in examining instruments of a similar kind. He has contributed, also, a neat and accurate method of observing azimuth, (Appendix No. 27,) the details of which are therein succinctly and clearly given.

RECORDS AND RESULTS.

Satisfactory progress has been made in the preparation for publication of the volumes of records and results, for which special appropriations have been made. The chief part of the time and attention of Assistant J. E. Hilgard and others has been given to this, and I have given personal attention to the arrangement of the work and to the more important details. A volume containing the whole of the geodetic work of the year 1849 is nearly ready for publication. Considerable progress has been made with a similar volume for 1850, and with another giving the magnetic observations for a period of ten years.

A volume of telegraphic determinations for longitude is in preparation by Dr. B. A. Gould, jr., and another of the chronometric expeditions, to determine the difference of longitude between Boston and Liverpool, is in progress in the hands of Mr. Geo. P. Bond.

The material for a volume of sailing directions is nearly ready for the press, and the manuscript of a volume of Gulf Stream explorations is well advanced.

An interesting and valuable summary of the progress of geographical explorations on the Atlantic coast of the United States has been furnished, under my direction, by Dr. J. G. Kohl, similar in character to the historical account of the Western Coast mentioned in my report of last year. (Appendix No. 64, 1855.)

This work, continued down from the first discovery of the country to our own times, forms an introduction to the geography of the United States of the present date. It contains also a discussion of the derivation and orthography of the names of the principal capes, headlands, bays, rivers, &c., and under both of these aspects will find an appropriate place for publication with the records and results of the Coast Survey. The history of the Atlantic coast is given under the following divisions:

I. A general descriptive history of the discovery and subsequent exploration of the Atlantic coast of the United States.

II. A list of names of the principal bays, inlets, harbors, ports, cities, river entrances, islands, capes, rocks, &c., on the Atlantic or Eastern Coast of the United States, with notes on the several localities, and remarks on the discovery and first settlement of the different points.

III. A series of reduced copies from forty-one maps of the Eastern Coast of the United States, arranged in chronological order, from 1497 to 1684, with notes critical and explanatory in reference to each.

IV. A catalogue containing the titles of two hundred and ninety-one works relating to the history of explorations on the Eastern Coast, accompanied by notes setting forth the comparative value of the several works, the dates of which are comprised between 1519 and 1855.

V. A catalogue of one hundred and fifty-five titles, including atlasses and detached maps, or surveys made on the Atlantic coast of the United States, between the years 1612 and 1851.

Dr. Kohl has prepared also a memoir of the early history of discovery on that part of the coast of the Gulf of Mexico falling within the limits of the United States. This summary, from historical and hydrographic annals of the Gulf coast, has been deposited in the Coast Survey office, and is comprised in five principal divisions, viz:

I. A list containing the titles of two hundred and twenty-one printed volumes or manuscript papers relating to the Gulf of Mexico. These range in date between 1524 and the present year 1856. Critical notes are appended to the titles, marking the relative value of the works for purposes of historical interest.

II. A list of titles, with critical remarks on fifty-eight engraved or manuscript maps and various surveys of parts of the Gulf of Mexico, made between the years 1733 and 1851, exclusive of surveys and publications by the United States Coast Survey.

III. Copies of forty-eight printed or manuscript maps of the Gulf of Mexico, or parts of it, dating from 1500 to the year 1846, with critical and historical notes accompanying each title. The titles of the series are exclusive of those given in the separate list of maps and surveys.

IV. The history of exploration on the coast of the Gulf of Mexico from its discovery in 1492 to the establishment of a Bureau of Engineers in Louisiana in the year 1722.

V. A list containing the names of the several divisions, ports, bays, harbors, capes, rivers, islands, &c., on the Gulf coast of the United States, with the history of each name, and notes explanatory of its proper orthography.

A general historical map of the Gulf of Mexico, showing in colors the principal discoveries and their extent, prepared by Dr. Kohl, accompanies this comprehensive memoir.

The general scope of the treatises by Dr. Kohl is set forth in further detail in communications which he addressed to me on their completion. (Appendix, Nos. 65 and 66.)

The preparation of an index of memoirs and papers on subjects of science connected with the operations of the Coast Survey has been continued by Lieutenant E. B. Hunt, of the Corps of Engineers, who has given such time to it as could be spared from the engineer and light-house duties assigned to him by the Engineer Department. A report of the progress made, with general views in regard to the index, notices of some similar works, references to the works consulted, and many other interesting details will be found in the Appendix, No. 67. This index will form a part of the archives and as such will be published with the volumes of records and results. In connection with the subject of an index of papers, Lieutenant Hunt proposes (Appendix No. 68) that measures be taken to secure uniformity in the abbreviations of the titles of books, displaying forcibly the necessity for such measures, and showing that determinate principles may be laid down in making such abbreviations.

MISCELLANEOUS.

The results of the investigation made of causes which led to the explosion of a boiler on the steamer Hetzel are given in Appendix No. 70, as distinctly brought out by the commission of inquiry. The special appropriation for supplying a new boiler has enabled us to restore the present efficiency of that vessel.

Among the miscellaneous services rendered by the parties, were the setting afloat and towing into port, at Key West, of the American ship James Guthrie, stranded at the Tortugas, by the party of Lieut. Comg. Craven, in the steamer Corwin, and the keeping afloat and towing into port, at Gloucester, Massachusetts, of the British barque Adieu, found in a sinking condition, by the party of Lieut. Comg. S. D. Trenchard, in the steamer Vixen. (Appendix No. 69.)

On the breaking out of Indian hostilities in Washington Territory, and under the very threatening aspect which they assumed, Commander James Alden volunteered the services of the steamer Active to the commander of the Pacific squadron for war service. The offer was accepted, and the Active was sent to Washington Territory, where she rendered useful aid for several months. This was, of course, felt as delaying the work of the survey; but the exigencies of the case thoroughly justified the step in my own view and that of the Department. The thanks of the Navy Department were tendered by the Secretary in a letter to the Secretary of the Treasury, which is given in Appendix No. 73. The Active returned to the survey of San Francisco bay and of the Cortez shoal and coast near Santa Barbara, in March.

My communication to the Department in reference to Indian disturbances in Florida, as affecting the progress of parties assigned to duty on the peninsula, and reply thereto, are given in Appendix No. 72.

LIGHT-HOUSES AND AIDS TO NAVIGATION.

Reports have been made, upon the requisition of the Light-house Board, under the law, upon the localities named below, and are presented in the Appendix, Nos. 83 to 86.

1. Bower's beach, western side of Delaware bay.
2. Mouth of Old Duck creek, western shore of Delaware bay.
3. St. Andrew's bay, western coast of Florida.
4. Sand Spit, southeast from San Buenaventura, Santa Barbara channel.

In addition to these, the following recommendations of buoys have been made by the chiefs of hydrographic parties of the Coast Survey, and have been forwarded through the Secretary of the Treasury to the Light-house Board for their consideration.

1. Buoys at the entrance to Kennebec river.
2. Buoy near Halfway Rock, Casco bay.
3. Buoys on Stellwagen's reef, between Minot's and Scituate light.
4. Buoy on ridge fifteen miles eastward of Sankaty Head light.
5. Buoy on Edwards' Shoal, near Southern Cross Rip.
6. Designation of buoys on the Atlantic coast southward of Savannah.
7. Buoy on shoal eastward of St. Simon's bar, Georgia.
8. Buoy on the reef between Cape Florida light-house and Fowey Rocks.

The systematic provision for buoys on the Atlantic coast south of Tybee entrance, by Lieut. Comdg. Craven, is the result of much experience in the coast navigation between Tybee and Cape Florida. His remarks in reference to the subject will be found in Appendix No. 80, and other recommendations specified above, in Nos. 79, 81, and 82 of the Appendix.

OFFICERS OF THE ARMY.

During the past year four of the officers of the army serving on the Coast Survey have been detached, and four have been ordered to the work; so that the number on the first of November of this year is the same as at the same date last year, viz: eleven.

Captain A. A. Gibson, who was relieved to join his company in Florida, had rendered acceptable service in connection with the Drawing Division of the office for four years, and was particularly adapted, from his good taste and fertile invention, to the position. Captain W. R. Palmer, of the corps of Topographical Engineers, had served most efficiently as chief of a triangulation party, and has left the results of one of the best river triangulations which we have in the archives of the Survey. During the greater part of the past year, he was in charge of the Coast Survey office, and it is due to him to say, that, having examined the office at the beginning of his charge and at the close, so as to see the working of his supervision, the efficiency of his service was fully made manifest. A copy of the letter addressed to him on being detached will be given in the Appendix (No. 75.) Lieutenant W. P. Trowbridge, of the Corps of Engineers, rendered very effective assistance in my party for nearly two years, and then took charge of the tidal observations on the Western Coast, which he carried through with signal ability, meeting all the difficulties of the case from his abundant resources, and never flagging in his zeal. The permanent gauges were well established, and nearly all the temporary, for observations which entered into the scheme, were completed before he left the Western Coast, and was detached by the War Department from the Coast Survey. Captain H. W. Benham, of the Corps of Engineers, had, when relieved, recently returned from the examination of the engraving establishments abroad, on a successful mission to procure first-class engravers to supply deficiencies in our office. He had been in charge of the office about three years, and had conducted it with the zeal, industry, and ability which belong to his character. The loss of four experienced and efficient officers like these, makes itself decidedly felt in our small corps. It must be some time before their successors can begin to replace them in service.

OFFICERS OF THE NAVY.

The number of officers of the navy attached to the Coast Survey on the first of November was fifty-three, being six less than at the first of September, 1855. The number of engineers and assistants was the same as last year, namely, fourteen. No hydrographic chief has been relieved during the year, though several have expressed their readiness for other service. This has left us with experienced officers, and has sensibly told upon the work. Lieut. Comg. Berryman was detached for a short period (see Appendix No. 76) to make the deep-sea soundings across the Atlantic in the steamer Arctic, but was on his return re-attached to the Survey. The importance of the object for which his services were required warranted, as I thought, the postponement of the Gulf Stream work which had been assigned to him, and a ready co-operation by the loan to the Navy Department of the reeling engine for deep-sea soundings and other appliances which we had prepared.

ABSTRACT OF PROGRESS—SURVEYING YEAR 1855-'56.

I proceed to give a condensed statement of the progress of the survey during the past year, say to November 1, 1856, and to follow it by the estimates for the fiscal year ending July, 1858, adapted to the same scale of progress.

SECTION I. *Coast of Maine, New Hampshire, Massachusetts, and Rhode Island.—(Sketch A and A bis.)*—Two primary stations, Mt. Saunders and Mt. Desert, between the Penobscot and Frenchman's bay, have been occupied, and astronomical and magnetic observations made at the latter, and at S. W. harbor in its vicinity. The reconnaissance for the primary triangulation has been completed to Passamaquoddy bay, and the site of a base of verification has been selected on Epping plains. The secondary triangulation of the Kennebec has been extended to above Bath, Maine, and eastward on Sheepscot river. The topography of Cape Small Point and of the Kennebec entrance has been executed, and that of the approaches to Portland has made progress. The topography south of Plymouth, Massachusetts, and south of the Highland lights, Cape Cod, has been extended. Resurveys have been made of parts of Martha's Vineyard, encroached upon by the wash of the ocean. The hydrography of Kennebec river entrance and of Casco bay has been executed; that of the seacoast between Ipswich and Annis Squam, Massachusetts, has been completed; that of Massachusetts bay has been completed, including Cape Cod bay, and the ocean shore outside of Cape Cod peninsula; and progress has been made in the area between it and Nantucket on one side, and George's Bank on the other. The hydrography of the shoals north of Nantucket and of Muskeget channel has been completed, finishing thus the Vineyard and Nantucket sounds. The permanent tide-gauge at Boston has been kept up. The computations of observations have been made. Observations of moon culminations at Cambridge were kept up during the year.

The following maps, charts, and sketches, belonging to this section, have been drawn during the year: Portland harbor, scale $\frac{1}{10000}$, showing the wharf line; Boston harbor, $\frac{1}{40000}$, (additions;) Boston harbor, $\frac{1}{200000}$; Plymouth harbor, $\frac{1}{20000}$; Bass River harbor, $\frac{1}{40000}$; and Muskeget channel, $\frac{1}{60000}$, (additions.)

The following are in progress: seacoast from Portsmouth to Cape Ann, $\frac{1}{80000}$; Annis Squam and Ipswich harbors, $\frac{1}{20000}$; general coast chart from Cape Ann to Point Judith, $\frac{1}{400000}$; Massachusetts bay, $\frac{1}{80000}$; seacoast of Massachusetts, No. 1, including Cape Cod and Buzzard's bay, $\frac{1}{200000}$; Cape Cod bay, $\frac{1}{80000}$; and Eastern series, sheet No. 3, $\frac{1}{80000}$. The following have been engraved during the year: Portland harbor wharf line, $\frac{1}{10000}$; Ipswich and Annis Squam harbors, $\frac{1}{20000}$, as preliminary; Gloucester harbor, $\frac{1}{20000}$; Boston bay, $\frac{1}{175000}$; Boston harbor, $\frac{1}{40000}$; Stellwagen's Bank, second edition, $\frac{1}{400000}$, as preliminary; and Bass River harbor, $\frac{1}{40000}$. The engraving of the following is in progress: Portland harbor, $\frac{1}{20000}$; Plymouth harbor, $\frac{1}{20000}$; Monomoy shoals, $\frac{1}{40000}$; Muskeget channel, $\frac{1}{60000}$; and Eastern series, Nos. 1 and 2, $\frac{1}{80000}$.

SECTION II. *Coast of Connecticut, New York, New Jersey, Pennsylvania, and part of Delaware.—(Sketch B.)*—The resurvey of New York harbor, for the Commissioners, has been nearly completed. The triangulation has furnished points in the upper and lower bay, and the approaches, and in the Hudson, East, and Harlem rivers, and in part of Long Island sound, to the topographical parties. The shore-line of the harbor and bay was nearly completed last season, and this year the parties have been engaged in extending the topography inland, chiefly in these parts of the harbor and bay in the State of New York, including Staten Island, and the western part of Long Island, Manhattan Island, and the main, along the shores of Harlem river, of Hell Gate, and of the sound to Throg's Point, and on the shores of the Hudson to Yonkers. Maps of the city wharves and Commissioners' lines have been constructed on a large scale for New York, Brooklyn, and Williamsburg. A resurvey has been made of the harbor inside of Sandy Point, near Stonington, Conn. The hydrography of the approaches to New York bay has been completed, and also that of Harlem river, and of the sound, between Hell Gate and Throg's Point.

A preliminary triangulation of the Hudson, from Troy to New Baltimore, has been in progress, and the shore-line has been traced, and a hydrographic survey based upon these preliminary operations, including the observations of tides and currents. Special observations have been made to ascertain the causes of the growth of Sandy Hook, the point of meeting of the tides in the Kills, and the progress of the tide wave up the Hudson, for the Commissioners on Harbor Encroachments.

The tidal observations at Governor's island have been continued in connection with others specially made at stations on Hudson river. A special examination of part of Newark bay was made, and investigations of the tides of the Passaic river. The following drawings have been made or in progress:

New York bay and harbor, $\frac{1}{10000}$, comparative chart, and a finished map of the same, $\frac{1}{20000}$, both for the Commissioners on Harbor Encroachments; Sandy Hook, $\frac{1}{20000}$, showing changes from 1779 to 1855; Hudson river, from entrance to Sing Sing, $\frac{1}{60000}$, and Hudson river, between Albany and New Baltimore, $\frac{1}{10000}$, comparative chart. The engraving of Hudson river, lower sheet, $\frac{1}{60000}$, preliminary chart, has been completed, and that of south side Long Island, Nos. 2 and 3, $\frac{1}{80000}$, is in progress.

SECTION III. *Coast of Delaware, Maryland, and part of Virginia.—(Sketch C.)*—The secondary triangulation of the James river has been nearly completed to its mouth, and that of the York river from the mouth to Purtan island. The topography of the Rappahannock has been continued to near Tappahannock, and that of the shores of the Chesapeake adjacent to the mouths of the Potomac and Rappahannock rivers has been executed. The topography of the seacoast has been extended from Assowaman inlet to Assateague island. Verification work has been done on the eastern shore of Maryland, near the Elk river. The hydrography of the approaches to the Chesapeake and of Tangier sound has been completed, that of the Rappahannock river has been carried to station Punch Bowl, and of the James river from Hog island to Chickahominy river.

The magnetic elements have been observed at seventeen stations connected with the triangulation on the eastern shore of Maryland and Virginia, and at Washington, Baltimore, and Cape Henlopen. The tidal observations at Old Point Comfort have been continued, and observations made at stations on the Patapsco, Rappahannock, and James rivers. A finished map of Patapsco river, (additions,) $\frac{1}{60000}$, has been drawn, and the drawings of Chesapeake bay, No. 2; Rappahannock river, sheets Nos. 1, 2, 3 and 4, $\frac{1}{20000}$, and James river, from Richmond to City Point, $\frac{1}{40000}$, are in progress. The following have been engraved: Seacoast of Virginia and entrance to Chesapeake Bay; Delaware and Chesapeake bays, $\frac{1}{400000}$, (preliminary;) and James river, $\frac{1}{40000}$, (preliminary.) The engraving of the following is in progress: Chesapeake bay, Nos. 1 and 2, $\frac{1}{80000}$; Patapsco river, $\frac{1}{60000}$; Rappahannock river, sheets Nos. 3 and 4, $\frac{1}{20000}$.

SECTION IV. *Coast of part of Virginia and of part of North Carolina.*—The triangulation of the ocean shore has been closed in a preliminary way upon that of the Chesapeake near Cape Henry, and extended from New river, south, to within twenty-seven miles of New Inlet, Cape Fear. Topography has been executed in connection with the triangulation southward to Stump

Inlet. The hydrography has been carried from Hatteras to Portsmouth, south of Ocracoke Inlet. Wilmington has been connected for telegraphic difference of longitude with Columbia, S. C. The drawing of the following maps and charts have been completed: Seacoast of Virginia, south of Cape Henry, $\frac{1}{200000}$, as preliminary; Albemarle sound, $\frac{1}{200000}$, as preliminary; Cape Fear river, upper and lower sheets, $\frac{1}{30000}$, and Gulf Stream chart, $\frac{1}{5000000}$. The following have been engraved: Cape Fear river, lower sheet, $\frac{1}{30000}$, as preliminary; Albemarle sound, $\frac{1}{200000}$, as preliminary; Gulf Stream explorations, 1855, $\frac{1}{5000000}$, and diagrams, wind and water, Albemarle sound; and Cape Fear river, upper sheet, $\frac{1}{30000}$; Albemarle sound, No. 2, $\frac{1}{80000}$; Beaufort harbor, North Carolina, $\frac{1}{20000}$, on steel; and isogonic lines, Atlantic and Gulf coast, $\frac{1}{5000000}$, are in progress.

SECTION V. *Coast of part of North Carolina, of South Carolina, and of Georgia.—(Sketch E.)*—The triangulation has been carried from the Cape Fear southward to Lockwood's Folly, North Carolina; along South Edisto river, and over St. Helena sound, to the Hunting islands, South Carolina; over Sapelo entrance and approaches, Georgia; over St. Simon's entrance and Brunswick harbor; and part of Cumberland sound has been triangulated. The topography connected with the triangulation south of the Cape Fear, of St. Helena, and the vicinity of St. Simon's entrance and Brunswick harbor has been executed. Verification work has been executed of Georgetown entrance and in Winyah bay. The hydrography of the ocean shores from Charleston to Tybee has been completed; and St. Helena sound and South Edisto river entrance have been sounded out.

A new channel across Martin's Industry shoals has been found.

St. Simon's bar, Turtle river, and Brunswick harbor have been sounded out, and Cumberland or St. Mary's entrance. Off-shore soundings have been made from Cape Fear to off Tybee and southward. The tidal observations at Charleston have been kept up.

Drawings of Georgetown harbor and Winyah bay, $\frac{1}{40000}$, preliminary chart, (additions;) Maffitt's channel, 1852 to 1856, $\frac{1}{5000}$; Charleston bar, 1850 to 1855, $\frac{1}{10000}$; Port Royal entrance and Beaufort harbor, $\frac{1}{60000}$; Savannah river to the head of Argyle island, $\frac{1}{40000}$; and Romerly marshes have been made during the year; and Winyah bay and Georgetown harbor, $\frac{1}{40000}$, preliminary; Maffitt's channel, diagram; Maffitt's channel, comparative chart, $\frac{1}{5000}$; Romerly marshes, $\frac{1}{10000}$; and Savannah river, $\frac{1}{40000}$, preliminary, have been engraved. The engraving of Port Royal entrance, $\frac{1}{60000}$, preliminary, is in progress.

SECTION VI. *Coasts, reefs, and keys of Florida.—(Sketch F.)*—The triangulation of Fernandina harbor and St. Mary's river has been completed. A base of verification has been measured near Jacksonville, for the triangulation of the St. John's. The triangulation of the keys and reefs has been carried eastward from Loggerhead key to Jacob's Point, (Key Vacas.) The topography has closely followed the triangulation, extending eastward to Summerland Key, and embracing Sugarloaf, Loggerhead, Cudjoe, Gopher, and several smaller keys.

The hydrography has extended from Grecian shoal to French reef westward, and eastward from Key West to Loggerhead key. Off-shore soundings have been made from off Tybee to Cape Cañaveral. Tidal and current observations were made in the St. John's river. Temperature observations have been made in the Gulf Stream off this section.

The following drawings have been completed during the year: St. John's river, $\frac{1}{25000}$; Legaré anchorage, and Tampa bay, and Florida reefs, $\frac{1}{200000}$, (preliminary;) ditto, $\frac{1}{80000}$, (finished,) are in progress; and sketch of beacons on Florida reefs, Legaré anchorage, and Tampa bay have been engraved.

SECTION VII. *Part of the coast of Florida.—(Sketch G.)*—The triangulation south of Cedar keys and over Waccasassa bay has been extended southward; that of St. Mark's harbor and approaches completed, and commencement made at Apalachicola; that of Pensacola bay and its dependencies has been nearly completed. The topography connected with these triangulations has kept pace with them nearly, at Cedar keys, St. Mark's, Apalachicola, and Pensacola.

The hydrography of St. Mark's harbor has been executed; that of St. Andrew's bay has been completed; and that of Waccasassa bay and St. Martin's reef has made progress.

Deep-sea soundings have been made, and temperatures taken across from Key West to the mouth of the Mississippi.

A finished chart of Cedar keys, $\frac{1}{50000}$, (addition,) and map of St. Andrew's bay have been drawn during the year, and preliminary charts of Cedar keys and approaches, $\frac{1}{50000}$; and St. Andrew's bay, $\frac{1}{400000}$, have been engraved.

Section VIII. *Coast of Alabama, Mississippi, and part of Louisiana.—(Sketch H.)*—The primary triangulation of Mississippi sound has been completed, and the triangulation has been carried across Lake Borgne; New Orleans has been connected with Mobile by a preliminary work. Astronomical observations have been made at Montgomery, Alabama. The triangulation of Chandeleur sound has made good progress. The triangulation of Atchafalaya bay is completed, and that of Côte Blanche bay has been commenced. A base at Point au Chevreuil has been selected for extending the work.

The topography of Lake Borgne has advanced; that of the Chandeleur islands and main made progress; that of the shores of Atchafalaya is very nearly completed; and of Côte Blanche bay commenced. The hydrography of Mississippi sound has been completed, and of Pass Christian to Pearl river; that of Chandeleur sound has made progress, and off-shore work has been executed.

The following maps, charts, and sketches, belonging to this section have been drawn during the year: Gulf of Mexico, (sketch for profiles of deep-sea soundings,) $\frac{1}{2400000}$; Gulf of Mexico, (sketch of Cotidal lines,) $\frac{1}{10000000}$; sea-coast of Alabama and Mississippi, as preliminary, $\frac{1}{200000}$; and Mississippi delta, (reconnaissance,) $\frac{1}{200000}$; the drawing of Biloxi bay, $\frac{1}{40000}$, is in progress; the engraving of Mobile bay, $\frac{1}{80000}$; Biloxi bay, $\frac{1}{40000}$, as preliminary; and deep-sea soundings, Gulf of Mexico, $\frac{1}{2400000}$, has been completed; and that of Mississippi sound, No. 1, $\frac{1}{80000}$, (finished,) and ditto, No. 2, $\frac{1}{200000}$, (preliminary,) and cotidal lines, Gulf of Mexico, 2 plates, $\frac{1}{10000000}$, is in progress.

Section IX. *Coast of part of Louisiana, and coast of Texas.—(Sketch I.)*—The triangulation has extended over nearly the whole of Matagorda bay and its dependencies; the topography following closely and taking in the neck of land seaward of Matagorda bay; the hydrography has been executed along the coast from off Cedar lake to the head of Matagorda bay.

The drawing and engraving of the preliminary chart of Galveston bay, $\frac{1}{200000}$, has been completed during the year.

Sections X and XI. *Coast of California, Oregon, and Washington.—(Sketches J and K.)*—The primary triangulation has advanced two stations north of San Francisco; the secondary triangulation, near San Pedro and Santa Barbara, has made progress. The triangulation in Washington Territory has been opened on the Straits of Fuca, and carried into Hood's canal; Possession sound, and through Admiralty inlet southward to Vashon's island, and that of Port Discovery has been completed. A base has been measured at Port Townshend. Astronomical observations have been made at Point Hudson. The topography of San Francisco bay and its dependencies, San Pablo bay, the straits of Karquines, Mare Island straits, and vicinity, has been completed; that near San Pedro has made progress, and also that on the shore of Santa Barbara channel. The survey has been completed of Anacapa, and part of Santa Cruz island, and that of Port Townshend, Port Gamble, and the topography of Apple Cove, and Murden's Cove has been executed.

The hydrography of San Francisco bay has been completed, the Cortez shoal has been carefully examined, and the southern side of San Clemente island. San Diego harbor has been resurveyed, and a bar found off the entrance; the currents of Santa Barbara channel have been observed.

The tidal stations have been kept up at San Diego, San Francisco, and Astoria, and observations made with the self-registering gauge at all of them.

The following maps and sketches belonging to these sections have been completed during the year: Anacapa and part of Santa Cruz, San Francisco entrance, Shoalwater bay extension, New Dungeness harbor, Port Ludlow, Port Gamble, Steilacoom harbor, and Bellingham bay. The following have been engraved: S. Farallon island, Alden's reconnaissance, upper sheet, and cotidal lines of the Pacific; and the engraving of Anacapa island, San Francisco entrance, Port Ludlow, Bellingham bay, Steilacoom harbor, and Port Gamble, is in progress.

ESTIMATES.

As the prices of all commodities and of labor increase in our country, the amount of work which we can execute for a given appropriation is of course diminished. The present scale of the appropriations does not quite meet this increase, and may fall so far short of it as to require a new appeal in regard to it. This I shall of course avoid, if it is at all possible. The expenses of the parties in the sections on the Gulf of Mexico are also considerably greater than on the Atlantic coast.

The estimates for the next fiscal year are exactly the same as for the past, and suppose the same aid which is now furnished under the law by the War and Navy Departments, in the detail of officers for the land work and hydrography respectively.

The amounts thus estimated, and those appropriated for the present fiscal year, are given in parallel columns, as follows:

Object.	Estimated for fiscal year 1857–'58.	Appropriated for fiscal year 1856–'57.
For survey of the Atlantic and Gulf coast of the United States, (including compensation to Superintendent and assistants, and excluding pay and emoluments of officers of the army and navy, and petty officers and men of the navy employed on the work,) per act of March 3, 1843	$250,000	$250,000
For continuing the survey of the western coast of the United States, per act of September 30, 1850	130,000	130,000
For continuing the survey of the Florida reefs and keys, (excluding pay and emoluments of officers of the army and navy, and petty officers and men of the navy employed on the work,) per act of March 3, 1849	40,000	40,000
For running a line to connect the triangulation on the Atlantic coast with that on the Gulf of Mexico, across the Florida peninsula, per act of March 3, 1843	15,000	15,000
For publishing the observations made in the progress of the survey of the coast of the United States, per act of March 3, 1843	15,000	15,000
For repairs of the steamer "Walker," and of the sailing schooners used in the survey, per act of March 2, 1853	15,000	15,000
For fuel and quarters, and for mileage or transportation for officers and enlisted soldiers of the army serving in the Coast Survey, in cases no longer provided for by the Quartermaster's department, per act of August 31, 1852	10,000	10,000

ESTIMATES IN DETAIL FOR THE FISCAL YEAR 1857–'58.

General expenses for all the sections, namely: rent; fuel; materials for drawing; engraving and printing, and ruling forms; binding; transportation of instruments; maps and charts, and for miscellaneous office expenses; and the purchase of new instruments, books, maps, and charts $19,000

SECTION I. *Coast of Maine, New Hampshire, Massachusetts, and Rhode Island.* FIELD-WORK.—To continue the primary triangulation in *Maine*, east of the *Penobscot*, to include *Humpback*, and to measure the base of verification on *Epping plains*, and make the necessary astronomical and magnetic observations connected with them; to extend the secondary triangulation from the *Kennebec* eastward, and to commence that of *Penobscot bay*; to continue the topography of *Casco bay* and the *Kennebec river;* to continue the hydrography of *Casco bay* and of the *Kennebec*, and to commence that of *Penobscot bay;* to continue the topography of the shores of *Cape Cod bay;* to complete the hydrography of the approaches to *Massachusetts bay*, and the deep-sea work between the coast and *George's Bank*, and of *Cape Cod bay;* to continue observations of tides and currents at stations in the section, and to take views requisite for charts. OFFICE-WORK.—To make reductions and computations required; to continue the drawing of the coast chart of *Maine and New Hampshire*, and commence the engraving of the lower sheet; to commence the drawing of *Casco bay* and of the mouth of the *Kennebec;* to complete the drawing of *Massachusetts bay*, and to commence that of the seashore of *Cape Cod peninsula*, and to commence the off-shore chart between the coast of *Massachusetts* and *George's Bank;* to complete the engraving of eastern series No. 1, and to continue that of No. 2; to continue the engraving of the finished chart of *Portland* harbor, to commence that of *Casco bay*, and preliminary sketches of the sections, will require........ $41,000

SECTION II. *Coast of Connecticut, New York, New Jersey, Pennsylvania, and Delaware.*—To continue the triangulation, topography, and hydrography of the *Hudson;* to execute verification work in the section, and to continue observations of tides and currents; to continue the drawing and engraving of the *Hudson river* sheets, and of the necessary comparative maps; to complete the eastern and middle sheets, south side of *Long Island;* to commence the drawing of a combined series of *Long Island sound* and the ocean shore, and preliminary sketches for the section, will require........ 8,000

SECTION III. *Coast of Delaware, Maryland, and Virginia.* FIELD-WORK.—To make the astronomical and magnetic observations requisite at stations in the section; to complete the triangulation of the *York* river, and to commence that of the *Potomac;* to complete the topography of the *Chesapeake*, and to continue that of the *Rappahannock, York,* and *James* rivers, and of the outer coast of *Maryland and Virginia;* to continue the off-shore hydrography of the section, and that of the *James and York rivers.* OFFICE-WORK.—To make the reductions and computations required by the field-work; to continue the drawing of the lower series of the charts of *Chesapeake* bay, of the series of *James* and *Rappahannock, and York* rivers, and to execute the sketches of the section; to continue the engraving of *Chesapeake* bay Nos. 1 and 2, of *Rappahannock* river Nos. 1 and 2, of *James river* Nos. 1, 2, and 3, and of *York river*, will require........ 25,000

SECTION IV. *Coast of Virginia and North Carolina.* FIELD-WORK.—To make the astronomical and magnetic observations required at stations in the section; to measure bases of verification; to continue the triangulation of Pamplico sound; to complete the secondary connection with the *Chesapeake* triangulation; to complete the junction with the *Cape Fear* triangulation; to continue the topography north of *Currituck sound*, and of the sounds south of *Beaufort* to the *Cape Fear;* to continue the hydrography south of the line of the two States, south of *Ocracoke Inlet*, and from *Cape Lookout* south to *Beaufort;* to continue observations of currents in the Gulf stream. OFFICE-WORK.—To make the necessary reductions and computations; to continue the drawing and engraving of the seacoast of *North Carolina* south of *Hatteras;* of *Albemarle sound* No. 1; to complete the engraving of *Albemarle sound* No. 2, and of the *Cape Fear*, from the entrance to *Wilmington;* and to draw and engrave the sketches for the section will require... 30,000

SECTION V. *Coast of North and South Carolina and Georgia.* FIELD-WORK.—To continue the triangulation south from *Lockwood's Folly*, connecting the topography with it; to continue the main triangulation south from *St. Helena sound*, over the *Hunting Islands*, and north from *Charleston* towards *Bull's bay;* to complete the triangulation of *Wassaw, Ossabaw, Sapelo, and St. Catherine's entrances and approaches;* to complete the topography of the shores of *South Edisto* and the *Dawho rivers* of *St. Helena sound*, of the *Hunting Islands;* of *Sapelo and Ossabaw entrances,* of *St. Mary's and Fernandina harbor;* to continue the hydrography of the ocean coast, north from *Charleston* to *Cape Roman;* to complete the hydrography of *Brunswick* and its approaches, of *Sapelo, Ossabaw, Wassaw,* and *St. Catherine's entrances;* to continue tidal observations in the section, and current and other observations in the *Gulf stream* off the section. OFFICE-WORK.—To make the requisite computations; to continue the drawing of the coast chart south of *Charleston,* and to complete the drawing and engraving of the preliminary coast chart between *Charleston and Tybee entrances;* to complete the drawings and engravings of preliminary charts of *St. Helena sound and South Edisto river,* of *Port Royal entrance and Martin's Industry,* of *Doboy and St. Simon's entrances,* and of *Darien and Brunswick harbors,* of *St. Mary's entrance and Fernandina harbor,* and the sketches of the section, will require...... $33,000

SECTION VI. *Reefs, keys, and coast of Florida.*—(See estimate for appropriation for those special objects.)

SECTION VII. *Coast of Florida.* FIELD-WORK.—To make the necessary astronomical and magnetic observations at the stations; to continue the triangulation southward from *Waccassassa bay* and northward from *Cedar keys;* to connect the triangulation of *St. Mark's and Apalachicola harbors,* and to complete the approaches to *Pensacola bay;* to continue the connection of *St. Joseph's bay;* to follow these triangulations by the necessary topography; to continue the hydrography of *Waccasassa bay, St. Martin's reef* and approaches; to complete that of *Apalachicola* harbor and approaches, and of *St. George's and St. Vincent's sounds;* to continue that of *Pensacola harbor;* to make the requisite tidal observations for the section. OFFICE-WORK.—To make the reductions and computations; to continue the chart of approaches to *Cedar keys, Waccasassa bay,* and *St. Martin's* reef; to draw the charts of *St. Mark's and Apalachicola harbors,* and to commence their engraving; to commence the chart of *Pensacola harbor,* and to draw and engrave the sketches for the section, will require...... 35,000

SECTION VIII. *Coast of Alabama, Mississippi, and Louisiana.* FIFLD-WORK.—To extend the triangulation of *Chandeleur sound* and islands to the mouth of the *Mississippi;* to complete the triangulation of *Atchafalaya, Côte Blanche and Vermilion bays,* and to commence that of *Calcasieu bay;* to complete the topography of part of *Lake Pontchartrain* and of the neck between the *lakes* and the *Mississippi;* to continue the topography of *Atchafalaya bay* and its dependencies, and of *Calcasieu bay;* to complete the hydrography of *Louisiana sound* and of *Lake Borgne,* and the off-shore work connected with it; to continue the deep-sea soundings of the *Gulf of Mexico* in this vicinity; to make the necessary observations for tides, currents, and temperatures. OFFICE-WORK.—To make the reductions and computations of the work of the section; to continue the drawing of the series of *Mississippi sound* charts, preliminary and finished, and of the preliminary chart of approaches to the *Mississippi delta;* to commence the drawing of *Atchafalaya bay* and its dependencies; to engrave *Mississippi sound* No. 2, and to commence that of *Chandeleur sound,* and the off-shore chart of this part of the coast; and to engrave the sketches required for the section, will require...... 33,000

SECTION IX. *Coast of Louisiana and Texas.* FIELD-WORK.—To extend the main triangulation southward and westward of *Matagorda bay* and its dependencies, and to make the necessary astronomical and magnetic observations connected with it; to make the secondary triangulation and topography connected with this; to execute the hydrography from the head of *Matagorda bay* southward and westward, and to execute off-shore soundings in the section. OFFICE-WORK.—To make the reductions and computations of the section; to continue the drawing and engraving of the coast chart south and west of *Galveston bay*, and commence that of the off-shore or general chart of the same part of the coast; and to execute the sketches for the section, will require.. $26,000

SECTIONS X AND XI. *Western coast—California, Oregon, and Washington.*—(See estimate for special appropriations as provided for last year.)

Total, exclusive of *Florida reefs and keys*, and of *Western Coast.* 250,000

The estimate for the *Florida reefs, keys and coast*, and for the *Western Coast*, is intended to provide for the following progress:

SECTION VI. *Reefs, keys, and coast of Florida.* FIELD-WORK.—To continue the triangulation of the keys and reefs outside from *Key Vacas* eastward, and from *Key Rodriguez* westward, to connect the base at *Cape Sable* with the triangulation of the keys, and probably to extend the triangulation from *Cape Sable* towards *Shark river;* to continue the topography of the keys eastward from *Summerland's Key*, following the triangulation, and westward from *Key Rodriguez*, or to execute that of *Cape Sable Prairie* and its vicinity; to extend the hydrography eastward from *Loggerhead Key*, and westward from *Key Largo*. OFFICE-WORK.—To make the necessary computations and reductions; to continue the drawing and engraving of the preliminary and finished charts of the *Florida reefs;* to complete the drawing and engraving of the chart of *St. John's* river, and preliminary sketches for the section, will require.. $40,000

SECTIONS X AND XI. *California, Oregon, and Washington.* FIELD-WORK.—To continue the main triangulation north from *Sonoma mountain*, and south from *Monterey;* to extend the triangulation near *San Pedro*, and on the shores of the channel of *Santa Barbara*, and to the islands; to continue the triangulation of *Washington sound*, and of the islands between the *Straits of Rosario* and of *Haro;* to continue the triangulation of harbors in *Admiralty inlet, Puget's sound, and Hood's canal;* to complete the topography of *San Pablo bay*, the *Straits of Karquines*, and other dependencies of *San Francisco bay;* to extend that of the coast south of *Monterey;* to continue that of the main shores near *San Pedro and Santa Barbara;* to continue that of the harbors of *Puget's sound* and *Washington sound*, in connection with the work of triangulation; to complete the hydrography of *San Francisco bay* and its dependencies; to continue that of the coast south and north of *San Francisco*, near *San Pedro; Santa Barbara channel*, and in *Puget's sound* and its dependencies. OFFICE-WORK.—To make the computations and reductions; to continue the drawing and engraving of the finished chart of *San Francisco bay*, and to complete the preliminary chart; to draw and engrave the harbor charts resulting from the surveys, and to continue the coast chart north and south of *San Francisco;* to continue the engraving of the chart of *Washington sound;* of the harbors of *Puget's sound;* and the sketches required for the section, will require.. 130,000

For running a line to connect the triangulation on the Atlantic coast with that on the Gulf of Mexico, across the Florida peninsula, per act of March 3, 1843.......... 15,000

For publishing the observations made in the progress of the survey of the coast of the United States, per act of March 3, 1843.. 15,000

For repairs to the steamer "Walker," and of the sailing schooners used in the survey, per act of March 2, 1853.. 15,000

For fuel and quarters, and for mileage or transportation of officers and enlisted soldiers of the army serving in the Coast Survey, in cases no longer provided for by the Quartermaster's department, per act of August 31, 1852........................ $10,000

The amounts of these several estimates are identical with those for the same class of expenditures appropriated last year.

A detailed statement of work executed within the surveying season, arranged according to geographical sections, will now be given, followed by an account of the work at the Coast Survey office in Washington.

SECTION I.

FROM PASSAMAQUODDY BAY TO POINT JUDITH, INCLUDING THE COAST OF THE STATES OF MAINE, NEW HAMPSHIRE, MASSACHUSETTS, AND RHODE ISLAND.—(SKETCHES A, Nos. 1—4.)

The operations in this section, of which an account is given in this chapter, are the following: 1. The reconnaissance of a base of verification on Epping plains, in Maine, near the eastern end of the primary triangulation, and for the triangulation itself to the boundary. 2. The extension of the primary work, and the astronomical and magnetic observations connected with it, by the occupation of Saunders and Mount Desert stations, in Maine. 3. The secondary triangulation of the Kennebec river and eastward. 4. The topography of Cape Small Point and of the entrance of the Kennebec. 5. The topography of Portland city and its environs. 6. The topography of Duxbury, Massachusetts, near Plymouth. 7. The continuation of the topography of Cape Cod peninsula. 8. The resurvey of the shores of Martha's Vineyard and of Muskeget channel, Massachusetts. 9. The hydrography of the entrance to the Kennebec river, and completion of that of Casco bay, Maine, and of Ipswich and Annis Squam harbors, Massachusetts. 10. The hydrography of Massachusetts bay, in-shore and off-shore from Cape Cod, and seaward to George's Bank. 11. The hydrography of Nantucket sound and vicinity. 12. The continuation of tidal observations in Boston harbor.

The work in this section has been vigorously pressed forward, and the full number of parties has been employed which the appropriation permitted, for as long a time as the means or the season lasted. The progress made is quite satisfactory.

Reconnaissance.—The reconnaissance for the extension of the primary triangulation eastward has been completed. Assistant C. O. Boutelle, aided by Lieutenant J. C. Clark, U. S. A., resumed the examination of lines, after his return from Section V, and determined the scheme shown in sketch A, terminating just beyond the northeastern boundary, in a line joining Chamcook, on Passamaquoddy bay, with a station on Grand Menan island.

In July, I visited in person the site selected on Epping plains for a base of verification, the only practicable one which the reconnaissance of Major Prince and Assistant Boutelle had developed. The grading of this base will not be an easy task, but its ready connection with the triangulation, (sketch A,) and its admirable position so near the end of the work, make up for considerable disadvantages in other particulars. I have accordingly taken steps to ascertain the cost of grading, and to prepare for measurement next season, if the appropriation will permit.

The points selected on the first reconnaissance for the primary series, Western Ridge, Moose-â-bec, proved, on close examination, not to be intervisible, and not to be easily rendered so; and Howard, on Buck's harbor, Machias bay, (sketch A,) was substituted for Moose-â-bec in the primary series.

There are now but five stations to be occupied in the primary series to carry it to the boundary. The ends of the base, and the special points selected for connecting the base and primary stations, will be occupied with the smaller instruments of the survey. I prefer to continue the policy heretofore explained in regard to this matter, namely, to keep the primary triangulation in advance of all the rest of the work, and to give as much time and personal service to other sections of the survey as is compatible with this view of my duties in Section I, in completing the primary triangulation.

Primary triangulation.—The party under my immediate direction was organized for work in this section on the 1st of June, and placed in charge of Assistant George W. Dean. Saunders mountain, in the township of Dedham, Hancock county, Maine, was occupied as a connecting link between the primary and secondary triangulations. The operations, confined mainly to geodetic and magnetic observations necessary at a subsidiary station, occupied the party until the 16th of July.

Preliminary arrangements having been made in the usual manner by Mr. Thomas McDonnell, the measurement of horizontal angles was commenced by Assistant Dean, on the 23d of June; and the weather proving highly favorable for progress, satisfactory determinations were made of angles connecting Saunders with five primary and the same number of secondary stations. Seven hundred and forty observations were thus made with the thirty-inch theodolite, (C. S. No. 1.) Vertical angles were measured upon all the signals by three hundred and forty observations with the eight-inch Gambey theodolite, (C. S. No. 57,) and one hundred and forty measurements with the Ramsden micrometer of the thirty-inch theodolite.

The observations for magnetic declination and intensity were made by Assistant Dean upon a plateau near the base of the mountain; (Saunders,) distant about half a mile, in a southwesterly direction from the geodetic station. Two hundred observations for declination were made on four days; two sets for horizontal intensity and moment of inertia, on two days, and four sets for determining the dip of the magnetic needle. The instruments used were the declinometer, D. 22, (C. S. No. 1,) and the ten-inch dip-circle (C. S. No. 4.)

Mr. Dean was assisted in making the arrangements necessary for posting the heliotropers, and in geodetic observations, by Lieut. J. D. Bingham, U. S. A., assistant in the Coast Survey, and during part of the time occupied at the station, by Sub-Assistant Stephen Harris. The aid of the party, Mr. James H. Toomer, assisted in the magnetic observations.

On completing the observations at Saunders, the party was transferred to the primary station, *Mount Desert* island, on the coast of Maine, where I rejoined it personally early in September. The station is on the eastern side of the island, and within three miles of the ocean.

Astronomical observations at Mount Desert.—The azimuth of the lines connecting this station with others in the primary triangulation was determined from ten sets of observations upon Polaris, when near its eastern elongation, and five sets upon λ Ursæ Minoris. These observations were referred, as usual, to an elongation mark, which was established at a point about four miles from the station. Each set consisted of five pointings upon the star, with the telescope direct, and the same number, telescope reversed, in connection with twelve sets of observations upon the mark, telescope direct and reversed.

The observations for latitude and time were made by Sub-Assistants Edward Goodfellow and Stephen Harris with the same instrument, in continuation of the investigations relating to personal equation as affecting observations with the zenith telescope. Those of Mr. Goodfellow for latitude consisted of one hundred and seventy-two sets upon thirty pairs of stars with the zenith telescope, (C. S. No. 5.) The value of one revolution of the micrometer of the instrument was determined by a hundred and seventy-eight observations upon the circumpolar star, 51 *Cephei*, near its eastern elongation.

Thirty observations were made with the micrometer upon a collimator adjusted to a sidereal focus, for determining the value of graduations on the level of the zenith telescope.

The observations for latitude by Sub-Assistant Harris consisted of one hundred and eighty-nine sets upon thirty-two pairs of stars. He made also one hundred and ninety-four observations upon Polaris near its eastern and western elongations for value of micrometer, and twenty-five observations upon a collimator for value of the level graduation.

The stars observed for latitude were, as far as practicable, selected from the Greenwich Twelve Year Catalogue, and the same pairs were observed by Mr. Goodfellow and Mr. Harris. The time requisite for the latitude and azimuth observations was determined by one hundred and twelve transits of high and low stars with the Würdemann portable transit, (C. S. No. 10.)

Geodetic observations.—These were somewhat impeded by the prevalence of fogs and by continued rains and cloudy weather, but were completed by the 14th of October, and before the closing of the astronomical work.

Twenty points were observed upon from Mount Desert, including eight primary and eight secondary signals; three light-houses (sketch A, No. 1) and the elongation mark already mentioned as the point to which the azimuth observations were referred.

The range of the longest line, namely, that connecting Mount Desert with Western Ridge station, is about fifty-nine miles. Three others of the lines observed during the season ranged between forty-five and fifty miles in length.

Besides those connecting the regular stations in the series of horizontal angles, observations were made to include also the highest peaks of Mount Katahdin and Passadumkeag mountain, which will serve to fix the directions of those prominent geographical features.

The number of observations made previous to the 14th of October, in the measurement of horizontal angles with the thirty-inch theodolite, was fifteen hundred and seventy-five.

In these and other duties pertaining to the regular operations of my party, I was ably assisted, as heretofore, by Mr. Dean.

Vertical angles, connecting with fourteen stations, were measured by Assistant Dean and Sub-Assistant Harris. For this purpose two hundred and thirty observations were made with the Gambey circle, and a hundred and fifty measures with the Ramsden micrometer, used in the early part of the season at Saunders station.

The area covered by the season's work of primary triangulation, estimated in the ordinary way, is about eleven hundred square miles.

Magnetic observations.—The geological formation of Mount Desert is sienite intersected with veins of quartz and occasional trap dykes of greenstone. Iron ore has been found upon its flanks, and the geological features presented at the summit led to the supposition that the magnets might be affected by local attraction. Arrangements were made accordingly for determining the magnetic elements in the immediate vicinity of the geodetic station, and also near the village of Southwest Harbor, distant about five miles in a southwest direction from the summit of the mountain. The observations near the geodetic station were made by Assistant Dean and Sub-Assistant Goodfellow, and consisted of one hundred and seventy-five for declination on four days, two sets for horizontal intensity and moment of inertia, and four sets for dip. The magnetic observations at Southwest Harbor were conducted by Sub-Assistant Harris, aided by Mr. Jas. H. Toomer. Two hundred and thirty observations were made by them, for declination, on five days, two sets for horizontal intensity and moment of inertia, and two sets for dip.

The instruments used at both stations were the declinometer D. 22, (C. S. No. 1,) and dip-circle, (C. S. No. 4,) previously in use at Saunders station.

Meteorological observations.—The usual meteorological journal was kept during the season by Mr. R. E. Evans, one of the aids in my party. Observations for temperature were recorded in three hundred and four separate entries, and an equal number were made for the evaporating point.

Two hundred and eighty-three readings of the barometer (Green, No. 910, and Dent's aneroid, No. 8,520) were also recorded, with remarks on the prevailing winds and other conditions affecting the state of the atmosphere in the locality of the geodetic station.

Lieut. J. D. Bingham, U. S. A., assistant in the Coast Survey, who had joined my party early in the season, remained with it during the work at this station. The requisite observations having been satisfactorily concluded by the middle of October, I engaged personally, by request of the Commissioners on Harbor Encroachments, in the examination of progress made by the several parties then engaged in the survey of New York harbor and its vicinity. Assistant Dean and Sub-Assistant Goodfellow proceeded, under my instructions, to reorganize parties for the telegraphic determination of longitude between Montgomery, Ala., and Mobile. Lieutenant Bingham has since reported to Assistant H. L. Whiting, for duty in Section V, and Sub-Assistant Harris has been assigned to the party of Assistant J. E. Hilgard, in Section VIII.

Within the year the computations for latitude and magnetic determinations at Ragged Mount station, and all the computations depending upon the work executed by my party at Mount Harris in the following autumn, have been completed and deposited in the office.

Secondary triangulation.—The work on the Kennebec river has been continued above and to the eastward of Bath by Lieutenant A. W. Evans, U. S. A., assistant in the Coast Survey, and Sub-Assistant Benjamin Huger, jr. The occupation of some of the stations established last year was commenced in July, the observations being, however, much impeded in the latter part of that month by thick fogs and easterly storms. Certain stations near Bath were first reoccupied, and then lines were opened for carrying the triangulation up the Kennebec, and for extending it eastward on the Sheepscot river. The work was carried in this direction about ten miles. Several new stations were established, and a position selected from which to connect the series going up the Kennebec with that of Sheepscot river.

The plan adopted at the outset for conducting the secondary triangulation in this section is still adhered to, a series of first and second order triangles being established, the former well conditioned, and connecting with a tertiary series, intended to furnish points for the plane-table. The tertiary work upon the Kennebec was executed by Sub-Assistant Huger, aided by Mr. G. E. Humphries. In the progress of the season's operations, numerous points and several elevations were determined by Lieutenant Evans, and furnished for the use of the topographical party of Assistant I. Hull Adams, when engaged at the mouth of the Kennebec and in its vicinity.

In the joint work of Lieutenant Evans and Sub-Assistant Huger fourteen stations were occupied, and one hundred and thirty-nine angles measured upon seventy-four objects, by one thousand two hundred and eighty-one observations.

The measurements connected with the tertiary work were concluded on the 17th of September, after which Sub-Assistant Huger engaged in the erection of signals and in reconnaissance for carrying the work eastward. Advantage was taken by Lieutenant Evans and Sub-Assistant Huger, during intervals unfavorable for field-work, to complete the office-work depending upon the operations of their parties in Sections V and VII.

Operations were discontinued on the Kennebec at the end of October, when immediate preparations were made for the return of the schooner Hassler and the party of Lieutenant Evans to the coast of Georgia. Sub-Assistant Huger has since been assigned to duty in the party of Assistant Boutelle, to be engaged in prosecuting the primary triangulation northward of Charleston, S. C.

Ten volumes, containing the computed results of the secondary triangulation conducted by Assistant C. O. Boutelle in Casco bay, and from Saco river to the Kennebec, have been completed by him within the present surveying year and deposited in the archives.

Topography, mouth of Kennebec river, Maine.—A plane-table party was organized for this work by Assistant I. Hull Adams early in July, and continued in the field until the 10th of October. The survey was commenced at Cape Small Point, and the sheet includes the southern part of that peninsula, with the details requisite to fill up the outline traced by Assistant Gilbert in 1854. Proceeding from thence in an easterly direction, Assistant Adams traced the shore-line of the main to Hunniwell's Point on the western side of the Kennebec, and both banks of that river upwards to a distance of a mile and a half from the entrance. Seguin island, lying off and due south of the entrance, and the islands at the mouth of the Kennebec, are also included in the topographical sheet.

The shore-line of the main and of the islands was furnished, as required, to the hydrographic party of Lieut. Comg. Trenchard.

Mr. Adams was assisted during the season by Mr. H. S. Duval. The work here noticed was executed after that to be referred to, as prosecuted early in the season by Assistant Adams on the Rappahannock, and his preparations are already complete for resuming the topography on that river.

Topography of Portland.—After the return of Assistant A. W. Longfellow from duty in the schooner Meredith, as will be noticed under Section V, his party completed the topography of Cousin's island, in Casco bay, and commenced the plane-table survey of the environs and city of Portland. "This work was very tedious, from the numerous interruptions and delays in the crowded streets; but the result is a very accurate plan of the city, showing the actual location, and size, and shape of the buildings."

"In surveying the environs, all conspicuous objects in the city were determined in position before running out the streets; and these, in addition to the triangulation signals, furnished numerous test points, which gave the most satisfactory means of comparison. The streets were first chained, to determine their length, width, and the angles of intersection with others, and afterwards for the purpose of determining in position the houses and other features of detail."

"In these operations an aggregate linear distance of seventy-three thousand four hundred and twenty metres was chained, exclusive of offsets, or forty-five and six-tenths statute miles."

"The aggregate length of the streets within the city limits, as shown on the map, is forty miles, and the number of separate buildings three thousand eight hundred and ten, exclusive of blocks of stores and other consecutive ranges. The length of wharf line, determined on the harbor, is seven and a half miles."

The survey of the city nearly completes the data for the publication of the finished chart of Portland harbor, but the completion of contouring in the environs was not found practicable within the season. It will be resumed and finished as soon as possible in the ensuing year. It has been found by several trials more economical as well as more satisfactory to make regular surveys of the cities than to rely upon local maps.

Assistant Longfellow expresses his obligations to the Hon. James T. McCobb, mayor of Portland, for courtesies extended, and prompt attention in furnishing means to facilitate the operations of his party. He mentions also in terms of commendation the activity and efficiency of the aid in his party, Mr. N. S. Finney.

The schooner Meredith had been kept in good repair throughout the season, and in the middle of November sailed for the coast of Georgia, where Mr. Longfellow is under instructions to commence the topography of Sapelo entrance.

Mr. Finney has been assigned to the charge of a party to act in concert with that of Sub-Assistant Bagwell in the schooner Joseph Henry for the execution of the topography southward from Cedar keys, Florida, and his preparations will shortly be completed for that duty.

Five sheets of tracings of the shore-line of Casco bay, east of Portland, were furnished during the season by Assistant Longfellow, for the use of the party of Lieut. Comg. Trenchard while engaged in the hydrography of Portland harbor.

The computations of his field-work of Section V were completed and duplicated in the course of the summer, and have been deposited in the office by Mr. Longfellow.

The schooner Meredith, being at anchor in Portland harbor on the morning of the 12th of October, was happily the means of saving the lives of some fishermen, whose boat was swamped in the attempt to reach their own vessel. The sailingmaster of the Meredith, Mr. John T. Hopes, with one of the hands, promptly pulled out and fortunately succeeded in their rescue.

Topography of Duxbury, Massachusetts.—Commencing at the limit reached in this vicinity in a former season, Assistant R. M. Bache made a proper connection with his sheet of Plymouth bay, and set up the necessary signals for continuing the plane-table work. These preliminaries were completed at the end of July. The plane-table work was then carried forward in the direction of Marshfield. The sheet, which occupied the party until the 1st of October, includes the town of Duxbury. Within its limits, twenty-three miles of shore-line and nineteen miles of roads were surveyed, and proportionately a large aggregate of detail in the included area of four square miles. The work was advanced about halfway towards Marshfield, and the natural features at the point reached are such as to present no obstacle to its rapid continuance in that direction.

The preparations of Assistant Bache have been completed for his return to Section VIII.

Topography of Cape Cod Peninsula.—Sub-Assistant C. T. Iardella completed as soon as practicable the inking of his topographical sheets executed in the winter and spring on the Florida keys, and early in July commenced a resurvey of Monomoy Point. This was carefully made, and the result showed that the point had made to the southward about sixty metres, while a corresponding length had been washed away from the western side. The northern point proved to have extended nearly eighty metres since the first survey was made. It was also found that the long narrow shoal inside of the "Powder Horn" had gained about a hundred metres in length and breadth.

On the 2d of August, Sub-Assistant Iardella commenced near Orleans joining his sheet with previous work of Assistant H. L. Whiting and the late Assistant Glück. Working to the southward, he completed the details requisite to fill the space intervening between Orleans and Nausett harbor. The operations of the party were discontinued on the 10th of October, with the following results:

Shore line surveyed	55 miles.
Roads surveyed..	33 miles.
Included area (square miles)......................................	10.

The shore line comprises the several features of ponds and creeks, and the marshes in the vicinity of Nausett harbor. That portion of the peninsula embraced in the topographical sheet of this season is for the most part destitute of upland vegetation, but abounds in peat swamps.

The arrangements of Sub-Assistant Iardella have been made for an early return to the Florida keys (Section VI) with the schooner Agassiz.

Resurvey on shores of Vineyard sound and Muskeget channel.—In order to ascertain the extent of changes known to have been occasioned by the action of the sea in the southeastern part of the Vineyard sound, an examination has been made by Assistant H. L. Whiting in that vicinity, including also the shores of Muskeget channel. His resurvey commenced as early as the nature of the season would admit, and was carried on at intervals of favorable weather until its completion on the 8th of May.

The natural changes which were found to have occurred were at once reported to the office, with the sheet containing the revised shore lines, and have been presented in the new edition of the chart of Muskeget channel (Sketch No. 6) accompanying my report of last year.

I subjoin entire in the Appendix (No. 13) the report of Assistant Whiting in reference to the character of the changes developed in his resurvey. He was previously engaged in the verification of work in Section III, and is now employed in the execution of topography for the Commissioners on Harbor Encroachments, to be noticed under the head of Section II.

Three topographical sheets of work executed last season have been sent to the archives by Assistant Whiting, viz: vicinity of Hyannis and Bass river; north shore of Cape Ann, including Essex river and Rowley river, with part of Plum island, to Newburyport. These maps are on the scale $\frac{1}{10000}$.

Hydrography of Kennebec river, Maine.—Soundings were commenced by the party of Lieut. Comg. S. D. Trenchard, U. S. N., Assistant in the Coast Survey, with the steamer "Vixen" and her boats, on the 2d of October, at Cape Small Point, and from thence the work was carried directly eastward to the entrance and up the Kennebec to a line abreast of Cox's Head. Seguin island, lying off the entrance of the river, is within the limits of the hydrographic sheet.

The following is extracted from the general report of Lieut. Comg. Trenchard:

"The Kennebec river may be entered either to the eastward or northward of Seguin island. The western passage is wider, and, for working in, may be considered preferable; but deeper water can be carried in from the eastward, between White Ledge and the 'Whale's Back,' which is a small rock lying to the southward of Salter's island. Both channels may be deemed good for vessels of any class, the least depth in one being from twenty-four to twenty-seven feet, and there is in the other over thirty feet at ordinary low water. The shoalest water was found between Wood island and White ledge."

"Opposite Pond island, and at about two-thirds of the distance in a direction towards the southern point of Salter's island, lies a rock, upon which, at extreme low tide, there is but eighteen feet water, and at times the sea breaks on it. I would recommend that a buoy be placed on this rock, and another upon White ledge, about three-quarters of a mile to the southward of Seguin island; and that buoys be placed also upon the other ledges to the southward and westward, upon which the sea breaks in rough weather."

In prosecuting the work off, and in the entrance to the Kennebec, four hundred and fifty-three miles were run in making five thousand eight hundred and fourteen soundings. Seven hundred and ten theodolite and a hundred and twenty sextant angles were observed. Fourteen miles of shore line were furnished by Assistant I. Hull Adams, in charge of the topographical party for hydrographic purposes.

The tide-gauge used for the reduction of soundings was located at the wharf of Hunniwell's Point, and arrangements were made for continuing the observations after the steamer "Vixen" left the river with the party, for the purpose of establishing a plane of reference.

Lieut. Comg. Trenchard, as before mentioned, returned by the way of Portland to New York, and was soon after transferred to the command of the surveying schooner "Gallatin." His preparations are now nearly complete for resuming hydrographic duty in Section V.

The steamer "Vixen" was reassigned to Lieut. Comg. Berryman, on the return of that officer from the special service upon which he had been detailed, by the Hon. Secretary of the Navy, in the United States steamer "Arctic."

Hydrography of Casco bay, Maine.—Lieut. Comg. Trenchard, in the steamer "Vixen," reached Portland on the 16th of September; but, in consequence of bad weather, was unable to commence the soundings requisite to continue the hydrography of Casco bay until the 24th, when the work was taken up at the eastern point of Great Jebeig island, and carried westward, between it and Little John's and Cousin's islands, to a junction with the northeastern limits of work previously completed. In the discharge of this duty, two temporary tide-gauges were established—one at Portland, and the other on the shore of Great Jebeig island; two hundred and fifty-nine angles were observed, and two thousand four hundred soundings were made.

On completing this work, the party proceeded to the mouth of the Kennebec. Later in the season, and while on the return from that quarter, Lieut. Comg. Trenchard determined the position of a rock on which the steamer "Daniel Webster" struck in Casco bay, on the afternoon of the 13th of October.

He reports that the rock lies directly in the track of steamers passing to and from the eastward, and that it may have less than eight feet water at very low tides. It bears N. by E. ½ E. by compass from *Half-way Rock*, and lies about three hundred yards from it. Other particulars respecting this danger, in the ordinary course of vessels in and out of the bay, will be found in Appendix No. 9.

Hydrography of Ipswich and Annis Squam.—The unfinished work of a previous season in the bight northward from Cape Ann, has been completed within the present surveying year by Lieut. Comg. Trenchard, in the steamer Vixen. The vessel reached Plum island, off Ipswich, Massachusetts, on the 15th of August, and, after erecting the necessary signals, the party proceeded to fill with soundings the space intervening between that entrance and Annis Squam. The work was extended to the northward and eastward, over Essex bar, and carried also within the Essex river, to a distance of two miles from its mouth.

Lieut. Comg. Trenchard reports that six feet can be carried over the Essex bar at low water, and that within, the channel deepens from two to over four fathoms. He remarks, also, "that soundings upon Ipswich bar, made in passing out and in, correspond with those laid down on the Coast Survey chart of 1855, and the buoys appear to be in good position."

In completing the hydrography of the vicinity, one hundred and thirty eight miles were run while sounding, and four hundred and fifty-five theodolite and sextant angles were observed. Eight thousand casts of the lead were made in from one to twenty fathoms water. Three stations for current observations, and three temporary tidal stations, were occupied. The work was completed on the 15th of September, when the vessel sailed for Portland.

Lieut. Comg. Trenchard, on reaching Cape Ann in the steamer Vixen, on the morning of the 14th of August, fortunately fell in with the British barque *Adieu*, then in a sinking condition, off the Salvages, and towed that vessel safely to port. The service so promptly and opportunely rendered by himself and the officers and crew of his command, were cordially acknowledged by the British consul at Boston, and by the parties interested in the vessel thus rescued by the Vixen from the most imminent peril. Copies of correspondence relative thereto will be found in Appendix No. 69.

Hydrography inside and off shore from Cape Cod peninsula.—(*Sketch No.* 2.)—The party of Commander H. S. Stellwagen, U. S. N., assistant in the Coast Survey, having completed repairs and outfit necessary for the season's cruise of the steamer Bibb, arrived at its station with that vessel in July. Taking a departure from the immediate vicinity of Monomoy light, a line of deep-sea soundings was run from thence eastward, traversing the supposed situation of "Clark's Bank." The line was there deflected to the southward and eastward, and, after being continued below the latitude of Nantucket, was again extended northward as far as George's Bank. Keeping soundings in the return from George's Bank, a line was carried about fifty nautical miles to the southward, and from thence westward to Monomoy. These lines can be readily traced in Sketch No. 2. Several detached spots were found, with from nine to fifteen fathoms water, to the southward and westward of George's bank, in positions for which no soundings have been given on published charts. In all probability, the existence of these becoming incidentally known, and being erroneously laid down in various authorities, first gave rise to the impression that two well-defined shoals perhaps existed midway between George's Bank and the Cape Cod peninsula. The lines of soundings already mentioned were crossed by four others about forty miles in length, and nearly equidistant, and, in connection with those run in the previous three years, they develop in a measure the hydrography of this important locality. The non-existence of "Clark's Bank," "Little George's," and "Crab Ledge," was satisfactorily proved, and the further researches made by Commander Stellwagen have developed the limits, extent, and general character of an immense continuous shoal ground, occupying an area of at least twelve hundred square miles, and lying westward, southwest, and southward from George's Bank. This space was traversed by Commander Stellwagen by numerous lines, and its continuity proved within a thirty-fathom curve. The least water found on the supposed locality of "Crab Ledge" was eighteen fathoms.

In the progress of operations by the hydrographic party, the positions were determined of nine points of rock, constituting a *reef*, between Scituate light and Minot's light. The depths in this range, which I propose to call *Stellwagen's Reef*, vary between four and eighteen feet; and though sufficient water is found between the rocks, their proximity to each other makes this a very dangerous locality. Four of them, most to be avoided on account of their position, have on them respectively only nine feet, nine feet, twelve feet, and fourteen feet water.

Off Webster's Flagstaff a sunken rock was detected with only six feet water on it. This rock lies about three quarters of a mile due east from one on which a buoy has been placed. To this fact the attention of the Light-House Board has been called in a communication made through the department.

Commander Stellwagen found also, and determined the position of a dangerous rock, with as little as six feet water, near Saquish Head, entrance to Plymouth harbor. The peak is quite sharp, and, although lying in the way of vessels beating in for the harbor, it is difficult to find.

With other developments made by the hydrographic party, it will be found marked on Sketch No. 2.

The positions of three rocks lying off Manomet Point were fixed, and it is proposed by Commander Stellwagen to call them the *Mary Ann Rocks*, after the name of a British vessel lost on them some years ago. These are partly bare at low water.

A detached tapering rock in this vicinity, with but six feet water, lying off Indian Hill, and about four miles to the northward of Manomet Point, was fixed in position and entered on the chart of the season. It is extremely dangerous. One of two buoys furnished by the Light-House Inspector was placed on it by Commander Stellwagen. The other he fixed on a rock having only four feet at low water, (Howland's Ledge,) found outside of "Sunken Rock," near Brandt Point, and determined its position. High Pines Ledge, inaccurately placed on some charts, was also surveyed and determined.

About six miles N. E. $\frac{1}{4}$ N. (magnetic) from Barnstable light a ledge was discovered, the existence of which seems to have been entirely unknown even to the resident fishermen and frequenters of that locality. Four fathoms water occur on it, and adjacent soundings gave eight, nine, and ten fathoms. It has already been resorted to, under the impression that it will be found a most productive fishing ground.

Later in the season the party of Commander Stellwagen found and determined a ledge of rock off Kettle island, near the entrance to Gloucester harbor.

The deep-sea soundings run in prosecuting the regular hydrographic work, in addition to those before described, consisted of four lines, viz: one eastward from Cape Cod, passing northward of George's Bank, and extending to longitude 66° 30′ W., and from thence returning in a nearly parallel westerly direction, and terminating at Cape Ann. The distance to which these two lines were carried seaward, measured in the same direction, is about a hundred and seventy miles. Between them two others were run eastward, and terminating about seventy-five miles from Stellwagen's Bank. These four lines indicate the existence of continuous deep water eastward of the entrance to Massachusetts bay, and between it and the meridian of George's Bank. The traverse lines referred to as intersecting with the soundings, carried eastward from Cape Cod peninsula, cross also the lines described above. Southward they connect with the hydrography off Nantucket sound, and while engaged on them near that limit of the season's work, the party discovered a new shoal in latitude 41° 27′ N., and longitude 69° 51′ W. It lies in the middle of the ship channel, between Great Round shoal and McBlair's shoal, and the least water found on it was twelve feet. (See Appendix No. 11.) A shoal spot, with but thirteen feet, was found at the northern extremity of Little Round shoal, and two distinct ridges off the northern end of Davis' Bank. The positions of these are described in the same Appendix, (No. 11,) and will be found on Sketch No. 3.

At favorable intervals the boat-work necessary along the outer shore of Cape Cod peninsula was completed, and the inshore hydrography southward from Nausett light, abreast of Chatham, and extending below Monomoy, was executed. The concluding work of the party of Commander Stellwagen was the prosecution and completion of the hydrography of Cape Cod bay. The soundings were made to connect at a line joining Race Point and Manomet Point, with previous work in Massachusetts bay.

The report of Commander Stellwagen presents the following aggregate of statistics recorded in the execution of the regular hydrographic work:

Miles run in soundings	2,634
Number of soundings	32,757
Angles determined	1,577

Having completed the detached hydrography requisite for charts of the vicinity, to be included within the limits of his general operations, Commander Stellwagen closed his work on the 15th of October, and returned with the steamer Bibb to New York. The vessel has since been assigned for the use of the party under Lieut. Comg. C. R. P. Rodgers, to be employed in Section IV on the coast of North Carolina.

The revised chart of Stellwagen's Bank, scale $\frac{1}{80000}$, and original chart of hydrographic work between Race Point and Nausett light, scale $\frac{1}{40000}$, together with journals of soundings, angles, current observations, and twenty-three specimens of sea-bottom from that locality, have been deposited in the archives by Commander Stellwagen.

Hydrography of Nantucket sound and vicinity.—(*Sketch No.* 2.)—The surveying schooner Gallatin, with the party of Lieut. Comg. C. R. P. Rodgers, U. S. N., assistant in the Coast Survey, began the regular work of the summer in Nantucket sound, on the 2d of June. The steam yacht Fire Fly, having been hired for the season, was assigned as a tender to the Gallatin, and joined that vessel in the middle of July.

"During July, and the early part of August, the progress of work was much impeded by the unusual prevalence of haze and fog. Many miles of soundings were run, but day after day, upon communicating with the theodolite observers on shore, it was found that they had not been able to follow us with their telescopes, and that part of our labor had been fruitless."

"The first efforts were directed to the survey of the sand ridges crossing the channel between the Great and Little Round shoals, and to a re-examination of Great Round shoal itself. This task was peculiarly difficult; the haze which prevails in that vicinity, the rapid tides, the rough sea, and the broken character of the bottom, presented obstacles to be surmounted only by the most patient perseverance. The little steam tender was invaluable for this service, and without her aid the party in the Gallatin could not have performed the duty to which it was assigned."

Lieut. Comg. Rodgers remarks also in reference to this particular locality:

"I am led to consider the channel between the two Round shoals as unsafe for vessels drawing more than ten feet water. Across it run sharp ridges of sand only a few feet wide, having deep water on either side of them. Over these the tide runs with such velocity as to render it almost impossible to keep a steamer steady while passing over their narrow crests. When the tide is slack, there is no visible sign of their existence, and it is only through a strong current that they can be traced or surveyed."

"The ridges of loose sand are doubtless subject to frequent changes, but no changes were detected in the Great Round shoal since our examination made last summer, (1855.)

"Having connected the survey of Commander McBlair on the south with that of Lieut. Comg. Woodhull on the north, we turned attention to the survey of the eastern part of Nantucket sound, and after its completion ran lines of soundings through the spaces left unfilled in the hydrographic work of previous years."

"The month of September was devoted chiefly to the survey of Cotamy bay, or the upper bay of Edgartown; to the work on the northern shore of the sound, including a re-survey of the Horse Shoe, Eldridge's, and the Wreck shoals; and to the hydrography of the unfinished space north of Holmes' Hole, and of the middle ground at the junction of Nantucket and Vineyard sounds."

"The latter part of August and part of the month following were favorable for work, and, by diligently improving good weather, the survey of Nantucket sound was completed early in October."

"The changes of the shore-line at Monomoy have been very great. The northwest point of Monomoy harbor has extended itself into the channel, so that there is now dry land where the Gallatin passed last year in two fathoms water. A sand hill four miles further to the northward, on which we placed a large tripod in 1855, has entirely disappeared, and its site is now covered with water."

The following aggregate of results is appended to the report of the able and accomplished officer under whose command the intricate hydrography of Nantucket sound and its vicinity has been at length completed:

Miles run in sounding	1,600
Sextant angles recorded	3,823
Theodolite angles	2,262
Total number of soundings	37,119

Lieut. Comg. Rodgers has deposited in the office the chart of Nantucket sound, scale $\frac{1}{50000}$, containing the results of his work of last season, together with fifteen volumes of recorded soundings and angles, in duplicate; and two volumes, each in duplicate, of tidal observations made by his party in the same year at Tuckernuck, Hyannis, Martha's Vineyard, and Muskeget island.

After closing for the season in this section, the hydrographic re-survey was made by the party, in the schooner Gallatin, of the vicinity of Sandy Point, near Stonington, Connecticut, which will be further noticed under Section II.

On returning to New York, Lieut. Comg. Rodgers was assigned to the command of the Coast Survey steamer Bibb, and on the completion of his office-work now in hand, his preparations will be made for the prosecution of hydrographic duty in Section IV, on the coast of North Carolina. The schooner Gallatin has been transferred to Lieut. Comg. S. D. Trenchard, U. S. N., under instructions for service in Section V, on the coast of Georgia.

Tidal observations.—The permanent tidal station at the dry dock of the Charlestown navy yard, Massachusetts, has been kept up throughout the season, and the records of the gauge, which has been in charge of Mr. Isaac Williams, have been punctually forwarded to the office. It is due to this observer to say that the reductions of his observations of former years show the care and fidelity with which they have been made. The resulting discussion is referred to in the preliminary part of this report, and in Appendix No. 34.

SECTION II.

FROM POINT JUDITH TO CAPE HENLOPEN, INCLUDING THE COAST OF CONNECTICUT, NEW YORK, NEW JERSEY, PENNSYLVANIA, AND PART OF DELAWARE. (SKETCH B, No. 5.)

The work in this section has been executed chiefly at the request of the Commissioners of New York on Harbor Encroachments, (see Appendix No. 47,) and at the expense of the State, by authority of the President of the United States and Secretary of the Treasury. It has consisted of the following operations, which are noticed in detail and with the usual statistics in this chapter:

1. Of triangulation in New York bay and harbor, and on the Hudson between New Baltimore and Albany, under the direction of Assistant Edmund Blunt, aided by Lieutenants A. H. Seward, J. C. Clark, and A. P. Hill, U. S. A., and by Sub-Assistants Charles Ferguson and George H. Bagwell.

2. Of topography in the environs of New York, by Assistant F. H. Gerdes, aided by Sub-Assistant J. G. Oltmanns; by Assistant H. L. Whiting; by Assistant S. A. Gilbert, aided by Sub-Assistants Sullivan and Seaton; by Mr. Boschke, aided by Messrs. Mechan, Balbach, and Dorr.

3. Of topography on the Hudson, between New Baltimore and Albany, by Assistant A. S. Wadsworth, aided by Mr. Strausz.

4. Of hydrography off New York entrance, and in Raritan bay, the East river, Long Island sound to Throg's Point, and Harlem river, by Lieut. Comg. T. A. Craven, U. S. N., assistant in the Coast Survey.

5. Of hydrography of the Hudson, between New Baltimore and Albany, by Lieut. Comg. Richard Wainwright, U. S. N., assistant in the Coast Survey.

6. Of a re-examination of the approaches to Stonington, Connecticut, by Lieut. Comg. C. R. P. Rodgers, U. S. N., assistant in the Coast Survey.

7. Of observations of tides, tidal currents, &c., in New York harbor, at Sandy Hook, in the

Kills, Newark bay, and the Passaic river, under my immediate direction, by Sub-Assistant Henry Mitchell.

8. Of observations of tides in the Hudson, under the direction of Lieutenant W. P. Trowbridge, United States Corps of Engineers, and of Mr. Gustavus Würdemann.

Triangulation.—In continuation of the work begun last year for the Commissioners on Harbor Encroachments, Assistant Edmund Blunt resumed the field on the 4th of April, and has since been incessantly employed in restoring, where practicable, the old points of reference in the triangulation, and in determining new ones for the use of the topographical and hydrographic parties. He remarks that "the destruction of points formerly used, by improvements, necessitated in this season the use of the tops of buildings in order to connect the work with the triangulation made in 1834 and 1835."

"Several points of a permanent nature on Manhattan island have been marked, and as soon as the iron tower now in progress of erection is finished, its position will be determined, in order to prevent difficulty hereafter in case other surveys shall be required."

"There are some places also on Staten Island, in New York city, and in New Jersey, which can be secured so as to be available at all times, notwithstanding the changes which may occur in the march of improvement."

In prosecuting the work of the present season, Assistant Blunt occupied twelve primary and a hundred and fifty-four secondary stations. The statistics of observations made at these, are as follows:

Number of series measured on primary signals	48
Measurements of primary angles	498
Number of series measured on secondary signals	1,349
Measurements of secondary angles	7,682

The data furnished by the labors of Mr. Blunt from time to time throughout the summer and autumn, were furnished at once as the basis of the topography executed by Assistants Gilbert and Whiting, and of the hydrography of Lieut. Comg. Craven. Checks were furnished also for mapping the wharves of New York city and Brooklyn, and for the detailed topography of Harlem river in charge of Mr. A. Boschke.

Sub-Assistant Charles Ferguson served in the early part of the season, under the direction of Assistant Blunt. His party was later joined by Lieutenant J. C. Clark, U. S. A., assistant, and Sub-Assistant G. H. Bagwell. At the close of the surveying year, Lieutenant Clark was detailed for triangulation work on the Florida keys. This duty devolved on him in consequence of the serious illness of Sub-Assistant Sullivan, to whom it had been assigned. Sub-Assistant Bagwell is completing preparations to proceed, under my instructions, to execute triangulation on the western side of Florida peninsula.

Under the direction of Assistant Edmund Blunt, a series of triangles, commencing at New Baltimore, was carried northward on the Hudson river to within a mile of the city of Albany.

The details of this work, intended to furnish the means of comparison with surveys made of that part of the river in previous years, were executed by Lieutenant A. H. Seward, U. S. A., assistant in the Coast Survey. Lieutenant A. P. Hill, U. S. A., assistant, was associated with Lieutenant Seward in field service, and at the close of operations was assigned to duty connected with the charge of the Coast Survey office.

The work on the Hudson river was begun on the 8th of July, and continued until the 1st of October. Lieutenant Seward reports as statistics:

Main signals erected	24
Secondary signals erected	54
Main stations occupied	16
Secondary stations occupied	33
Number of sets of repetitions	612
Single observations made in measuring angles	3,666

The area covered by the triangulation is about twelve square miles.

Lieutenant Seward has already left this section to resume duty at Cape Sable in connecting the base with his triangulation executed in previous seasons southward from Cape Florida.

Topography of the environs of New York city.—Assistant F. H. Gerdes resumed, on the 1st of July, the field-work requisite to fill in detail the topographical sheets commenced last year by himself and by Sub-Assistant J. G. Oltmanns, under his direction. Within the season, the resurvey for the Commissioners on Harbor Encroachments has been completed on both shores of the East river, from the mouth of Harlem river to Throg's Neck. The topography of the interior of Long Island eastward as far as to include Jamaica, and southward to a junction with the work of Assistant Gilbert, has also been executed. The limit in that direction reached, in the operations of Assistant Gerdes, ranges eastward and northward from the head of Gowanus bay, by a curved line, through the villages of Mount Prospect, Bedford, and Centreville, to beyond Jamaica.

The details are comprised on five plane-table sheets, the first of which includes the topography of the interior from Kingsbridge to Throg's Neck, on both shores of East river. Thirteen villages are embraced and represented within its limits. A second sheet comprises the interior of Long Island, from Astoria to White Stone, with three towns. The shore line of this and that of the first sheet mentioned was traced by Assistant Gerdes last year. The interior, extending from Astoria and Green Point to Flushing and Jamaica, constitutes, with six other towns and villages, the prominent details of a third sheet begun and completed this season. The fourth contains the topography of Long Island immediately adjacent to New York city. This sheet extends to East New York, and includes the consolidated cities of Brooklyn, Williamsburg, and Green Point, with five villages and towns. The concluding work of Assistant Gerdes on Long Island embraces on a fifth sheet the interior between East New York and Jamaica, both of which are represented on it.

The five sheets above described were completed previous to the middle of October, and present the following aggregate of statistics:

Miles of roads surveyed	362
Miles of marsh-line	52
Miles of shore-line of rivers and creeks	35
Area represented by the sheets	87 square miles.

Assistant Gerdes has since filled in the topographical details of his sheet of Hudson river, carrying the work from Hoboken, on the western shore, and above Spuyten Duyvel Creek on the eastern, upwards, and terminating for the season at Palisade Point, above Fort Lee.

Mr. Charles H. Boyd and Mr. R. E. Halter served as aids in the party.

Assistant Gerdes is now making arrangements for an immediate return to resume duties in Sections VII and VIII.

The office-work of these two sections depending on the field-work last executed, was brought up at intervals during the summer and autumn, and the records and resulting computations have been deposited in the archives.

Topography of southwestern part of Long Island.—Assistant S. A. Gilbert, who had commenced work in this locality, last season, tracing then the shore-line from Gowanus southward to Gravesend bay, and from thence the outer beach beyond Rockaway inlet, was preceded in the field-work of the present season by Sub-Assistants J. A. Sullivan and M. Seaton. Their operations were commenced on the 15th of July; but an accident to the schooner Petrel, and the illness of Mr. Sullivan, materially retarded progress, which would otherwise have been made previous to the arrival of Assistant Gilbert, on the 27th of August.

He at once made arrangements required by the circumstances of the parties under his direction, for pressing forward the plane-table survey of the interior.

Commencing at the western extremity of Long Island, the detailed resurvey for the Commissioners on Harbor Encroachments is now complete eastward to Far Rockaway, and from the Atlantic shore of the island northward to the limits of the work of Assistant Gerdes, finished also within the present season.

The results of Mr. Gilbert are comprised on five plane-table sheets: the first of which in the order of execution contains in detail the shores, islands, and topographical features of Jamaica bay, Pelican inlet, near the western, and Rockaway Pavilion adjacent to its eastern limits. Proceeding westward, a second includes the interior to Gravesend bay, and from Coney island to latitude 40° 37′ N., with the towns of Gravesend, New Utrecht, and Bath. A third embraces the details between Bath and Gowanus, the completion of which was much delayed by the prevalence of yellow fever in the district lying northward of Fort Hamilton. The fourth sheet extends the work eastward from Gowanus and the adjoining limits of the two last mentioned, to longitude 73° 55′ W., joining on the north with the plane-table work of Mr. Gerdes. The interior lying between the Long Island railroad and Jamaica bay, including the towns of Flatbush and Flat Lands, the villages of Greenfield, Tottenville, and Windsor Terrace, and adjacent features, comprise the details of the fifth sheet

Sub-Assistant Sullivan, in consequence of serious indisposition, was compelled to leave the field in September; his duties, then devolving on his aid, Mr. W. S. Gilbert, were judiciously and successfully conducted until the close of the season.

Sub-Assistant Seaton made the reconnaissance for points of reference in the work between Flatbush and Jamaica bay, traced sixteen miles of shore-line, and assisted in the topography of that vicinity; but was under the necessity of leaving, by reason of sickness contracted before the close of operations in the field.

Assistant Gilbert remarks as follows, on the character of the portion of Long Island falling within the bounds of his survey: "The country on which our operations were extended, excepting that in the immediate vicinity of Jamaica bay, is of a kind requiring the utmost care in order to insure accuracy."

The plane-table work was conducted by Assistant Gilbert with due regard to all the requirements likely to become desirable in the future development and improvement of the eastern part of Long Island. His plane-table work executed this season comprises, exclusive of the surveys of the towns already mentioned, forty-three miles of road and thirty-seven miles of shore-line, within an area of twenty square miles; seventy-eight miles of roads and forty-one of shore-line were traced by the party of Sub-Assistant Sullivan. The contouring and intricate portions of work falling on the several sheets were executed by Assistant Gilbert.

Arrangements are in progress for the return of the party to the work in Section IX.

Topography of Staten Island.—The shore-line of this island, a considerable part of which had been traced in the resurvey for the Commissioners on Harbor Encroachments, at the date of my last annual report, has since been verified, and the new survey of the entire island completed by the party of Assistant Henry L. Whiting. His party commenced in the field on the 11th of June, and the work was prosecuted with great diligence throughout the season, until the end of November.

At intervals during its progress, a plane-table, additional to that used by Assistant Whiting, was kept employed, under his direction and arrangement, by Mr. F. W. Dorr, the aid in his party.

The topographical resurvey of Staten Island is comprised in three sheets: the first of which includes the northeastern and middle part, extending as low down as a line joining Fresh Kills and Great Kills, together with the towns of Factoryville and New Brighton, on the northern shore; the Quarantine, Stapleton, and Vanderbilt's Landing, bordering on New York bay; and Sprayville, New Durp, and Richmond, in the interior.

The southern part of the island, terminating at Ward's Point, is embraced on the second sheet, and also the town of Rossville and Arthur Kill.

The topography of the third sheet, which contains the northwestern part of Staten Island, comprises in the survey the towns of Port Richmond, Frame Village, Old Places, and Chelsea.

The following remarks upon natural features, as coming under his notice in the field, are contained in the report of Assistant Whiting:

"Staten Island presents variety as great in the contrasts of surface as it does in scenery, and is certainly one of the most picturesque and beautiful of all the islands on the Atlantic coast. The highest land seems mostly confined to the northeastern part of the island, where some of the hills range over four hundred feet in height. These reach to the very shore on the north and east, and there develop into the pleasing villa sites of Clifton and New Brighton. Several valleys run through this high land in different directions, forming a most agreeable variety of hill and dale, the undulations of which admit of the highest degrees of cultivation. At the eastern side, bordering on the 'Narrows' of New York harbor, the range of high land leaves the shore, and trends southwesterly towards the middle of the island, where it abruptly terminates. Beyond this, and extending to the southern end, lies a level tract, richly and variously cultivated."

The statistics of the complete survey are thus stated in the season's report:

Shore-line represented on topographical sheet	54½ miles.
Length of creek surveyed	57 miles.
Outline of marsh	69 miles.
Roads	308 miles.
Area, in square miles	52

In reference to the survey, Mr. Whiting remarks: "Staten Island, in diversity of features, is one of the finest subjects possible for displaying the effectiveness and superiority of the system and style adopted for the topographical work of the Coast Survey."

Assistant Whiting executed, also, the topography of Bergen Neck, extending the detailed work from the point upwards, a distance of two miles and a half.

To Mr. Dorr, whose association, for two seasons past, in the field with Mr. Whiting, qualifies him for separate duty, I have assigned the execution of topography on the Florida peninsula.

When my report of last season was presented, the party of Assistant A. S. Wadsworth was still engaged in tracing the shore-line of Staten Island sound. Thirty-five miles of shore, additional to that previously reported, were transferred to the plane-table by himself, or by Messrs. H. S. Duval and J. Mechan, serving under his direction. This work, as before remarked, combines with the survey of the island, since completed by Assistant H. L. Whiting.

Topography from Sandy Hook westward.—In the prosecution of work for the Commissioners on Harbor Encroachments, Assistant A. M. Harrison traced, before the close of last season, the shore-line of Raritan and Sandy Hook bays, including that of Sandy Hook, as low down as Shrewsbury inlet; and his operations of the present year in this section were confined to the filling in with detail the three sheets then marked out. The first of these in the order of completion extends from Raritan river southeastward, along the coast of New Jersey, to the town of Union, which it includes, as well as the village of South Amboy and the town of Keyport. From the shore of Raritan bay the plane-table work was carried into the interior, and made to include a belt varying in width from a mile to a mile and a half.

The character of the upper or western part of this tract is hilly and wooded; that of the lower end level and thickly settled, cultivated, and intersected by many roads.

The second sheet, completed by Mr. Harrison, connects with the former at Union, and comprises the detailed topography of the shore and interior for a mile and a half, stretching southeast to the western base of the highlands of Navesink. The village of Port Monmouth is represented on this sheet with many farms and considerable forest land. The district included within its limits is generally level, excepting that falling on the eastern end of the sheet. The last topographical sheet, concluding the survey of the vicinity, contains the highlands of Navesink, Sandy Hook, and Shrewsbury bay and inlet.

Assistant Harrison took up the plane-table work of the interior in July, and completed his sheets finally at the end of the surveying year. He was aided by Mr. P. R. Hawley and Mr. W. H. Dennis, and during a part of the season by Mr. F. W. Alexander.

The schooner Benjamin Peirce was used by the party for transportation. At present, Assistant

Harrison is preparing the vessel and reorganizing his party for duty in Section V. On closing for the season, his topographical sheets were inked by Mr. Hawley, the aid of the party, and turned in for combination with the maps in progress for the Commissioners.

Special topography and maps of New York city and harbor.—In order to facilitate the progress of operations in the work undertaken for the Commissioners on Harbor Encroachments, Mr. A. Boschke, of the Drawing Division, was transferred to New York in May. He is still engaged in field and office duties immediately connected with the maps also in progress in his hands for the Commissioners. At the outset of the season, from data furnished by the triangulation of Assistant Edmund Blunt, lines were traced, under the direction of Mr. Boschke, upon the wharves and bulkheads of New York city, from the Battery to 55th street, North river, and to 38th street, on the East river part; and the wharves in Brooklyn, from Atlantic dock to Newtown creek. The aggregate of artificial shore-line thus minutely determined amounted to forty-five and four-tenths miles.

Mr. Boschke carefully resurveyed the shores of Manhattan island, above 55th street, North river, Spuyten Duyvel creek, and the shores of Harlem river, above 38th street, by the ordinary method employed in field topography, and made also a special survey, including Gowanus bay, between Atlantic dock and 29th street, Brooklyn.

The maps of these localities have been drawn on the scale of two hundred feet to an inch; and that of the survey and measurement of the wharves and bulkheads of New York city, on a scale of eighty feet to the inch, is nearly completed. The arrangement proposed for these, in atlas form, and of other works in progress, including the general chart of New York harbor and vicinity, projected for the Commissioners, is stated in the report of Mr. Boschke, Appendix No. 48. It is expected that the work now in hand may be finally completed early in the ensuing year.

Hydrography, (re-examination of Sandy Point, near Stonington, Conn.)—A resurvey of the shore-line of this vicinity, referred to in my report of last year, indicating that changes had probably occurred in the hydrography, the party of Lieut. Comg. C. R. P. Rodgers, U. S. N., assistant in the Coast Survey, after the completion of work in Nantucket sound, made a re-examination, in connection with a series of tidal observations, of that locality.

The chart, showing the nature and extent of the changes, Lieut. Comg. Rodgers reports as nearly ready for return to the office.

Hydrography of Hudson river.—The party of Lieut. Comg. Richard Wainwright, U. S. N., assistant in the Coast Survey, in the schooner Nautilus, on the first of August commenced the hydrography of the Hudson, about a mile below New Baltimore, and continued it up the river to the city of Albany. This work was directed in order to determine the character and extent of the changes which have occurred in that part of the river which includes the "*Overslaugh.*" A base was measured by Mr. A. Strausz, of the party of Lieut. Comg. Wainwright, upon a site selected by Assistant Edmund Blunt, and the requisite plane-table work commenced a little below New Baltimore.

The party was shortly after joined by Assistant A. S. Wadsworth, who remeasured the base and continued the topography of the banks of the river towards Albany, from the limit reached by Mr. Strausz.

The mean length of the base determined from the two measurements is 1,581.82 metres. Fifty-four and a half miles of shore-line were traced and furnished to the hydrographic party, by the joint labors of Assistant Wadsworth and Mr. Strausz.

The statistics of work executed by the party of Lieut. Comg. Wainwright are as follows:

Miles run in sounding	224
Angles observed	3,582
Total number of soundings	24,039
Current observations made	12

Three tide-gauges were employed in order to furnish means for reducing the soundings.

The results obtained in this survey will be combined on a map of comparison, showing the alterations of outline and of depth which have taken place since the survey made by the Engineer Department, in 1852–'53.

Lieut. Comg. Wainwright, on concluding work on the Hudson, resumed hydrographic duty on the Rappahannock, in Section III.

Several hydrographic sheets have been returned to the office by Lieut. Comg. Wainwright within the season, viz: three of Hudson river, extending from Castle Garden northward, Newark bay, Kill van Kull, and two sheets containing Arthur Kill sound, on the scale $\frac{1}{10000}$. He has deposited also the records and diagrams of current observations made at thirteen stations in the vicinity of New York city.

Hydrography of New York bay and harbor.—The hydrographic work of Lieut. Comg. T. A. Craven, U. S. N., assistant in the Coast Survey, in continuation of that begun last year for the Commissioners on Harbor Encroachments, was resumed in the steamer Corwin on the 17th of June. Soundings in the present season were extended from the Light-Ship through the Narrows and the entire eastern portion of the bay and harbor, together with East river to Throg's Point, Little Hell Gate, and Harlem river. For the data requisite in the reduction of the soundings, eight tidal stations were used by the party, and observations were made at twenty-five stations on currents. One hundred and twenty-five specimens of bottom were taken with soundings in various parts of the harbor and its dependencies. The work was discontinued on the 13th of November, at which time Lieut. Comg. Craven reported as the result of the season's operations:

Miles run in sounding	978
Angles determined	4,733
Total number of soundings	45,650

About fifty-five miles of water area were included in the soundings.

The following charts have been received within the season from Lieut. Comg. Craven: New York harbor, from Governor's island to Fort Hamilton, scale $\frac{1}{10000}$; a connecting sheet extending to Sandy Hook, and including part of Raritan bay, scale $\frac{1}{20000}$; a third, exhibiting the soundings between Jersey city and Williamsburg, scale $\frac{1}{10000}$; and a fourth, containing the results of soundings on Diamond reef and Coenties reef, scale $\frac{1}{2000}$.

Lieut. Comg. Craven has deposited also thirty volumes containing records of soundings, with duplicates, and the records of current observations made at eighteen stations in East river, together with eighty-eight specimens of bottom taken from New York harbor during last season.

Tides and tidal currents.—For the purpose of investigating the cause of changes in the shore-line at Sandy Hook, Sub-Assistant H. Mitchell commenced, under my instructions, in the winter, a series of elaborate observations and experiments in that vicinity. With a view to determine the nature of the currents and the course of their action as affecting the shores, objects of various specific gravities were used, the place of deposit by the action of the water under different circumstances being noted in the several cases.

The conclusions which I have drawn from these observations are of an important character, and will be found, briefly stated, in an abstract of a paper read to the American Association for the Advancement of Science, at their meeting in Albany last August, and which I append to this report. (See Appendix No. 38.) Sub-Assistant Mitchell conducted also the observations requisite in the investigation of the tides and currents of Newark bay and the Kills. Fifteen stations were occupied in connection with the tides of the bay and Kill van Kull and Arthur Kill, and nine in the observations on currents. At each station an observer on shore noted the rise and fall of the tide upon a gauge, while another, from a boat anchored in the stream, observed simultaneously the velocity and direction of the current. Several sets of stations were thus occupied daily during the progress of the work. Further remark in reference to the execution of this duty is contained in the report of Sub-Assistant Mitchell, Appendix No. 39.

In the early part of August eight tidal stations were established on the Hudson river, between Albany and New York city. The localities were selected, under my direction, by Lieut. W.

P. Trowbridge, U. S. Engineers, assistant in the Coast Survey, to whose efficient services, in connection with tidal operations on the Western Coast, I have elsewhere referred.

The gauges were placed at intervals of from twelve to twenty-five miles, varying according to the character of the river between the stations, as presenting more or less obstruction to the progress of the tide wave. The stations chosen were at Greenbush, (opposite Albany,) Castleton, Stuyvesant, Tivoli, Poughkeepsie, West Point, Verplanck's Point, and Dobb's Ferry. Regular observations were kept up as usual throughout the season at Governor's island, in New York harbor. At that station and at Greenbush, Saxton's relf-registering gauge was used.

The observations at the eight stations below Albany were conducted by Mr. Gustavus Würdemann. Bench marks were established and carefully secured for future reference, by inserting copper bolts in stone structures adjacent to the several stations used. The observations made throughout the season will be, as soon as practicable, reduced in the Tidal Division. Appendix No. 40 contains the report made by Mr. Würdemann on concluding operations for the season.

Special observations on the tides and currents of Passaic river were made, during the latter part of the summer, by Mr. Mitchell. These were undertaken for the determination of questions concerning the construction of bridges in the vicinity of Newark, N. J. In prosecuting this work, three positions were occupied and soundings made to determine the configuration of the bed of the river. The axis of the current was determined, and also its direction.

Sub-Assistant Mitchell was aided throughout the season by Mr. W. G. Williams, whose efficiency in the various duties assigned to him are warmly commended in the several reports of the season.

The observations with the self-registering tide-gauge at Governor's Island having been frequently interrupted by ice during the winter, a common box-gauge and a graduated staff were established at the Atlantic Ferry dock, in Brooklyn, to supply the necessary results. The expedient has proved successful, notwithstanding the extreme severity of the winter of 1855–'56, in which, however, a few instances occurred not admitting the use of either of the gauges, by reason of the piles of floating ice surrounding them.

In the spring the observations at Brooklyn were discontinued, and those at Governor's Island placed under the charge of Mr. J. B. Brooks, and have been regularly kept up.

Light-house examinations.—Under directions from the Department, re-examinations have been made by Lieut. Comg. C. R. P. Rodgers, U. S. N., assistant in the Coast Survey, in reference to the expediency of establishing light-houses at Bowers' Beach, and the mouth of Old Duck creek, on the western shore of Delaware bay. The results, as detailed in his report, (Appendix No. 84,) have been communicated to the Light-house Board.

SECTION III.

FROM CAPE HENLOPEN TO CAPE HENRY, INCLUDING THE COAST OF PART OF DELAWARE, MARYLAND, AND PART OF VIRGINIA. (SKETCH C, NOS. 7—12.)

Important magnetic observations have been made at the stations of the survey in this section. The main triangulation has been completed in former years, leaving only that of part of the rivers to execute. That of the rivers of Maryland, except the Patuxent and St. Mary's, has been also completed, and of the Rappahannock river, Virginia. The triangulation of James and York rivers has been in progress. Topography of verification has been executed on the Elk river, Maryland. The topography of the seacoast of Virginia, and of the shores of the Chesapeake bay, in Virginia, has also been in progress this year. The hydrography of Tangier sound, Va., and of the James and Rappahannock rivers, Va., has made good progress. The details of all these operations will be found in this chapter.

Magnetic observations.—During the months of August and September, Assistant Charles A. Schott, aided by Mr. J. L. Tilghman, determined the magnetic declination, dip, and intensity at seventeen stations, lying principally near the seacoast between Cape Henlopen and Cape Henry, viz: Washington city, D. C., two stations; Baltimore; Oxford, Maryland; Cape Henlopen; Dagsborough, Delaware; Mason's Landing, Maryland; Snead, Virginia; Joynes, Virginia; Scott, Virginia; Cape Charles; Old Point Comfort; Norfolk, two stations; Cape Henry; Fredericksburg and Richmond.

The declination and intensity were determined by magnetomer, (Jones) U. S. C. S., No. 6, and the dip by the dip-circle, (Gambey) U. S. C. S., No. 5; sidereal chronometer, (J. Fletcher,) No. 1,707, was used in the observations.

Before leaving, and after returning to Washington, the magnetic constants were carefully determined; the moment of inertia of magnet H was deduced from seven sets of observations by means of three inertia rings of very different weight. The temperature co-efficient had previously been known from careful observations; the co-efficient depending on the distribution of magnetism relative to the deflecting and deflected magnets, was determined from nine sets, and the magnetic moment of magnet H from twelve sets of observations. The cylindrical figure of the axes of the dipping needles was tested by means of twenty-eight sets of observations, by applying different weights, the results being deduced by Mayer's formula.

At each of the abovenamed stations the azimuth and time for the determination of the declination were obtained by means of the 5-inch horizontal and vertical circles of the magnetic theodolite from three sets of observations of the sun when near the prime vertical, comprising in all seventy-two separate readings. The intensity was obtained from two sets, repeated five times, of two hundred vibrations each, of magnet H, and the dip by four sets of observations, with needles No. 1 and No. 2, with polarity direct and reversed: in all, by two hundred and fifty-six separate readings.

The results of these observations are given in Appendix No. 30.

Triangulation of James river, Virginia.—This work has been continued in the direction of the river downwards from Little Brandon, the limit reached in the previous season by Assistant John Farley. Commencing on the 10th of October, the party of Mr. Farley remained in the field until the 31st of December. Operations were resumed early in May, and the triangulation was prosecuted until the 7th of July. The limit now reached in this work is at Hog island, below Jamestown, about twenty-five miles from the entrance of James river into Chesapeake bay, so that it will probably be completed this autumn, or early in the ensuing year.

The number of stations occupied within the season was twenty, and for purposes of verification six others were reoccupied. Twenty triangles were determined in a series with the 6-inch theodolites, (Brunner No. 66, and Gambey No. 76,) by three thousand three hundred and fifteen intersections.

Sub-Assistant Charles Ferguson assisted in the work in the former part of the season.

The original notes and records of the angular measurements made in the work on James and York rivers, and the resulting computations and descriptions of stations and signals connected with the triangulation of James river, have been turned in at the office by Assistant Farley.

Triangulation of York river, Virginia.—Under the immediate command of Lieutenant J. P. Roy, U. S. A., assistant in the Coast Survey, and the general direction of Assistant John Farley, a party was organized at the opening of the present surveying season for this work. Between the 1st of November and the 10th December, the triangles were extended from the entrance of the river, where the work joins the Chesapeake triangulation of Assistant Blunt, upwards as far as Green Point and King's creek.

Resuming operations on the 27th of March, Lieutenant Roy carried the series of triangles from King's creek up York river, and terminated the work of the season at Purtan island, about twenty miles from the mouth of the river. Eighteen triangles are included in the series, the angles of which were measured by two thousand observations with the 6-inch Brunner theodolite, C. S. No. 66.

Topography.—The verification of the plane-table sheet of the eastern side of Elk river, Maryland, from a point about two miles above the Frenchtown railroad depot, and extending to and including Bohemia river, has been executed by Assistant H. L. Whiting. The resurvey was carried throughout to the distance of three miles back from the shores of Elk river, the details within the limits stated being closely and thoroughly filled up. This work was completed in December, and the area embraced in verification is about thirty square miles. Assistant Whiting made in the same month an examination of the plane-table surveys of Rappahannock river, taking for that purpose the sheet containing the shores of the river between Tappahannock and a point six miles below the town.

The results have been reported as being generally satisfactory.

Assistant Whiting was subsequently employed in a resurvey, as noticed in Section I, and is at present with the other parties completing the topography required by the Commissioners on New York Harbor Encroachments, as stated under Section II.

Topography on the seacoast of Virginia.—Assistant George D. Wise, after completing his office-work of surveys made in the early part of the year in Section VII, resumed the topography of the outer coast of Virginia. Commencing at Assawaman inlet on the 18th of August, his plane-table work was extended northward to Snead signal, and eastward beyond the light-house on Assateague island. The shores of Chincoteague and Assateague inlets, and of numerous creeks connecting with them, are included in the details of his plane-table sheet.

The operations of the party were closed on the 30th of September.

A good deal of sickness prevailed among the hands employed in the field-work.

The statistics reported are as follows:

Miles of shore-line surveyed	50
Miles of roads surveyed	30
Square miles of area included	20

Early preparations will be made for the return of the party to resume the work in Section VII.

Seven topographical sheets of work executed during the last and previous seasons on the seacoast of Maryland and Virginia, have, within the year, been put in ink by Assistant Wise, and deposited in the archives.

Topography of shores of Chesapeake bay.—Assistant John Seib, after a short interval following his return from Section V, reorganized his party in the schooner Wave for topographical work on the shores of the Chesapeake bay. He left Baltimore for the mouth of the Potomac on the 16th of July, and completed the plane-table survey of the entrance to that river. His two sheets of this vicinity contain the shore-line and interior of Point Lookout, including the creek of that name on the northern side of the entrance; the topography of the southern bank of the Potomac from Hull's Neck outward to Smith's Point and the western shore of Chesapeake bay; from thence southward to the mouth of Great Wicomico river. Cupid's creek, Hack's creek, Little Wicomico river, and numerous intricate water-courses, are laid down amongst the topographical features occurring between the limits mentioned. The sheet containing the southern bank of the Potomac includes also the topography of the upper part of Great Wicomico river. Mr. W. H. Dennis aided Mr. Seib in the execution of this work, but was transferred to Section II shortly after the middle of August. Later in the season, Assistant Seib completed the topography of the entrance to the Rappahannock river. His sheet of that locality contains the adjacent western shore of Chesapeake bay north from Windmill Point and from Stingray Point southward to the Piankatank river, and includes also the topography of both shores of the Rappahannock river, from the entrance upwards to Stiff Point, on the southern bank. The limits on the northern side take in the shore-line and topography of the river about two miles above Mosquito Point. Sturgeon creek, Mosquito creek, and Stiff creek, are represented on the plane-table sheet. The statistics of the work executed are thus presented in the report of Assistant Seib:

Shore-line of rivers, creeks, coves, and ponds surveyed	144 miles.
Roads surveyed	34 "
Area, in square miles	29

Sub-Assistant Charles Ferguson joined the party on the 26th of August, and assisted Mr. Seib in topography until the close of the season. The schooner Wave was then refitted at Baltimore, and has now reached her station with the party of Assistant Seib for topographical duty in Section V.

Fourteen plane-table sheets of work previously executed on the Chesapeake by Assistant Seib, have been inked and returned by him to the office within the year. Portions of field-work on four sheets yet remain to be executed in order to complete the survey of the bay. These are registered in the archives as Nos. 495, 503, 504, and 507; and it is estimated that six months of continuous favorable weather in the field will suffice for the completion of the details required on them.

Topography of Rappahannock river.—The regular topographical survey of the Rappahannock river (sketch No. 7) has been extended from stations Punch-bowl—Downman towards the entrance, a distance of about six miles beyond the limits of last season's work, by Assistant I. Hull Adams. Early in June he furnished points on the shore for the hydrographic party then employed in the same stretch of the river, which has there a breadth of from two and a half to three miles.

The sheet of Mr. Adams, which connects with that of the previous year by Mr. Seib, embraces the opposite shores of the river, including the mouths of numerous creeks. It presents forty miles of shore-line and two miles of roads. The schooner J. Y. Mason served the party for transportation.

Assistant Adams has since his return from this section engaged in the prosecution of a topographical survey, already noticed under Section I, and is now completing preparations for resuming work on the Rappahannock.

Hydrography of Tangier sound.—(*Sketch No.* 7.)—The only extended portion of the hydrographic work of Chesapeake bay remaining unfinished at the opening of the season, has since been completed by the party of Lieut. Comg. J. J. Almy, U. S. N., assistant in the Coast Survey, in the steamer Hetzel.

The soundings commenced on a line joining Tangier island and the light-house south of Watts' island, and were carried from thence northward into and up the sound, and including its numerous dependencies, among which are the branches known as Big Annemessex river, Manokin and Wicomico rivers, Monic bay, Nanticoke river, Fishing bay, and Hooper's straits.

The work at the entrance was properly joined with the hydrography of Pocomoke sound, executed by the party in the previous season.

Numerous specimens of bottom taken in Tangier sound have been deposited in the office by Lieut. Comg. Almy. He reports as follows on the statistics of the work executed:

Miles run in sounding	574
Number of soundings	27,627
Angles taken by theodolite	134
Angles taken by sextants	2,243
Tides observed	74
Tidal observations recorded	1,027

Within the season Lieut. Comg. Almy has completed and deposited in the office his hydrographic sheet of Pocomoke sound with nine volumes of soundings, and twelve containing the records of angles taken in executing the work between Cape Henry and Pocomoke sound. These, together with two volumes containing the records of tidal observations in Chesapeake bay and Pocomoke sound, were accompanied by duplicates.

Hydrography of Rappahannock river.—The finished hydrography of the river has been carried within the present season downwards from Accaceek Point by the party of Lieut. Comg. Richard Wainwright, U. S. N., assistant in the Coast Survey, in the schooner Nautilus. The length of river course included in the soundings is about twelve miles and a half. A self-registering tide-gauge was established in the middle of May by Lieut. Comg. Wainwright at Tappahannock, and kept in operation during the progress of the hydrography.

Records have been made also from five other gauges established between Accaceek Point and the stations "Punch-bowl—Downman," at which the work of the season was closed on the 28th of June.

The hydrographic statistics are as follows:

Number of angles determined	1,269
Number of miles run in sounding	201
Total number of soundings	15,020

On returning from this section, the party of Lieut. Comg. Wainwright was transferred to Section II, and during the remainder of the summer engaged in the hydrographic reconnaissance of a part of Hudson river, as mentioned under that head.

Hydrographic sheets No. 9, No. 11, and No. 16, of Rappahannock river, scale $\frac{1}{10000}$, have been completed within the season and returned to the office by Lieut. Comg. Wainwright. He has deposited also eighteen volumes of soundings, and eight containing the recorded angles of the work in Rappahannock river, with duplicates, and notes of the tidal observations made in connection with the hydrography.

Hydrography of James river, Virginia.—The sounding of this river has been continued within the season by the party of Lieut. Comg. J. N. Maffitt, U. S. N., assistant in the Coast Survey, in the schooner Crawford. Operations were begun on the 9th of June, in the usual manner of this party, by the measurement of a preliminary base on Jamestown island, for the determination of the shore-line of the river. In connection with the hydrographic work, the shores of the James river were traced from Hog island upwards as far as Dancing Point, above the mouth of the Chickahominy. The work was prosecuted until the 1st of July, furnishing at that time the following statistics:

Number of angles of determination	260
Number of angles observed	1,196
Miles run in soundings	810
Total number of soundings	18,960
Miles of shore-line determined	30

The party of Lieut. Comg. Maffitt had been previously engaged in the extension of various hydrographic surveys in Section V.

Three sheets of the chart of James river, extending from Craney island to the limits last reached by Lieut. Comg. Maffitt, have been received at the office, together with two volumes, in duplicate of tidal observations recorded during the progress of the soundings.

Tidal observations.—The permanent self-registering tide-gauge at Old Point Comfort has been kept in operation as heretofore.

At the request of Major Henry Brewerton, of the Corps of Engineers, a self-registering gauge was loaned for use at Fort Carroll, on the Patapsco, and the results there obtained have been returned to the office.

A self-registering gauge was also established at Tappahannock, in the progress of the hydrographic work in Rappahannock river, by Lieut. Comg. Wainwright, as already mentioned.

SECTION IV.

FROM CAPE HENRY TO CAPE FEAR, INCLUDING PART OF VIRGINIA AND NORTH CAROLINA.—(SKETCH D, No. 13.)

In my report of last year I gave a general review of the progress of the operations in this section, and stated prospectively how they were to be carried to completion. The expected progress for the past year has been realized; the verification of the telegraphic difference of longitude between Petersburg, Va., and Columbia, S. C., was made by the new line between

Wilmington and Columbia; a preliminary connection has been made between the triangulation of Currituck sound and that of Chesapeake bay; the sea-shore triangulation has been carried south to within twenty-seven miles of Federal Point, on the Cape Fear; the topography in connection with this has made due progress, and the hydrography has been carried from Cape Hatteras to South Portsmouth, south of Ocracoke. Another season will, in all probability, complete the southern sea-shore triangulation of this section, and carry the hydrography nearly to the junction with the former work at Cape Lookout. In succession the plans explained in my report of 1855 will be carried into execution, and the survey of this section be completed about the same time as that of the third section.

The examination of Hatteras and Ocracoke inlets by Lieut. Comg. Almy has shown that, though the channels have shifted since the former survey, they retain their depths. The changes at Cape Fear entrance have also been observed by Lieut. Comg. Maffitt, consisting in a still further shoaling of the main bar and a deepening of the western channel.

The following maps and charts have been in progress, or have been drawn within the year: Seacoast of Virginia, south of Cape Henry; Albemarle sound; Cape Fear river, upper and lower sheets; and Gulf Stream chart, $\frac{1}{1000000}$. The following have been engraved, or are engraving: Cape Fear river, upper and lower sheets; Albemarle sound, (preliminary chart;) Albemarle sound, No. 2, (finished chart;) Beaufort harbor, North Carolina, on steel, as a finished chart; and the chart of Gulf Stream explorations, 1855.

Astronomical and telegraphic observations for difference of longitude.—The establishment by the Washington and New Orleans Telegraph Company of a new line for the telegraph between Wilmington, N. C., and Columbia, S. C., on the route of the Wilmington and Manchester railroad, presenting a desirable opportunity for the verification of the longitude results already obtained between Petersburg and Columbia, by the way of Raleigh, two parties were organized by Assistant George W. Dean, in November, for this purpose, and for extending the regular telegraphic operations, reference to which will be made under Section V.

The requisite instruments having been placed in adjustment at DeRosset station, in Wilmington, at the close of November, a full series of observations were made for personal equation by Assistant Dean and Sub-Assistant Edward Goodfellow, on the completion of which, the station was placed under charge of Mr. Goodfellow, and Mr. Dean proceeded to Columbia. Throughout the month of December, the unusual severity of snow and rain storms occasioned not only frequent interruptions in the regular business, but also caused great damage to the line; and, in consequence, it was found impracticable to commence the longitude experiments successfully until the 9th of January. On the 17th of that month, having exchanged star signals satisfactorily on four different nights, Assistant Dean returned to Wilmington, and again observed with Mr. Goodfellow for personal equation; after which, Mr. Goodfellow took charge of the station at Columbia. Frequent interruptions occurred to prevent the working of the telegraph line, arising chiefly from the continued severity of the winter, so that the requisite number of nights for exchange of signals was not obtained until the 17th of February.

At Wilmington, four hundred and eighty observations were recorded for local time and instrumental corrections. The equatorial intervals corresponding to the threads of the instruments were determined from eighty-three observations upon circumpolar stars, and the personal equation of the observers by seventy observations upon equatorial stars.

For the determination of difference of longitude between Wilmington, N. C., and Columbia, S. C., star signals were exchanged on six different nights, the observations being made upon one hundred and twenty stars.

At Columbia, between December 18th and February 20th, three hundred and sixty observations were made for local time and correction of instruments, and on circumpolar stars seventy observations were recorded for equatorial intervals.

The latitude and magnetic constants had been previously determined at Wilmington and Columbia by Assistant Dean.

The acknowledgments of Assistant Dean are expressed in the season's report for courtesies and willing co-operation extended to himself and the members of the parties under his charge by L. J. Fleming, Esq., general superintendent of the Wilmington and Manchester railroad.

The telegraph work in this section terminated on the 20th of February, when the parties were transferred to stations in Section V.

Computed results of the observations made at DeRosset, in 1854, for latitude, and for magnetic elements at that station and at Raleigh, in the same year, have been deposited in the office by Assistant Dean.

Secondary triangulation from Cape Henry southward.—A preliminary connection has been made by the party of Assistant J. J. S. Hassler, between the triangulation coming northward from Currituck sound and that of the Chesapeake, at Cape Henry. This work has proceeded under local difficuties peculiar to the stretch of coast along which it has been extended. The opening of some lines, in approaching the cape, was required where the surface presented was of swampy forest; and this is reported as being also the character of the region westward of Cape Henry, from which it is desirable to determine stations in connection for the topography and hydrography of Broad bay and Lynnhaven bay.

The season's operations of Assistant Hassler commenced at Green Branch signal, thirteen miles southward from Cape Henry; and in making the preliminary connection with Cape Henry east and the light-house, the following statistics were reported:

Stations determined	12
Number of observations	2,412
Area of triangulation, in square miles	25

Observations were made with the Gambey theodolite, C. S. No. 56.

The computations resulting from this work, with records of the angles measured and descriptions of signals, have been turned in at the office by Assistant Hassler.

Triangulation on the coast of North Carolina.—The party of Assistant A. S. Wadsworth commencing on the 10th of March at the stations "Skeleton—Macawber," the limits reached by him last year, has extended this work southward, closely following the coast to Rich inlet, which is twenty-five miles distant from the stations named.

"The progress of the triangulation was much impeded by the difficulty of transit, the creeks composing the sound (so called) interfering seriously with foot passage, though scarcely navigable for boats of the lightest draught."

Assistant Wadsworth had also charge of the party employed in topographical work in the vicinity.

The following are reported as statistics of the triangulation work executed up to the 18th of June, when the party was broken up:

Number of stations occupied	25
Number of signals observed on	29
Angles measured	76
Number of observations	2,901
Area of triangulation, square miles	22½

The angular measurements were made with the six-inch Gambey repeating theodolite, (C. S. No. 29.)

Mr. H. S. Duval served as aid in the triangulation party.

Assistant Wadsworth has deposited in the archives records of the angles observed, with a duplicate of the volumes containing them, and computed results for the length of lines.

Topography of the outer coast of North Carolina.—The plane-table party in charge of Assistant Wadsworth, beginning in March at a point about a mile north of New River inlet, carried the survey southward and westward along the coast, following closely the triangulation executed also under his charge, as already mentioned.

The sheets include the ocean shore, and in detail the numerous creeks and small sounds lying contiguous to the main, and extending down the coast to a point beyond Stump inlet, about midway in the triangulation of the present season.

The stretch of coast embraced in these two plane-table sheets is about fifteen miles.

The statistical results are as follow:

Miles of shore-line surveyed	255
Square miles of area	25

The topography was executed by Mr. John Mechan, attached to the joint parties in charge of Assistant Wadsworth, who, in reference to its quality as plane-table survey, remarks: "This work was executed with great energy and skill, and stood the test of a thorough examination."

The topographical sheets have been turned in at the office by Assistant Wadsworth.

In-shore hydrography, between Cape Hatteras and Ocracoke.—On the completion of repairs to the steamer Hetzel, rendered necessary by disaster, the details of which as occurring on that vessel are given in my report of last year, Lieut. Comg. J. J. Almy, U. S. N., assistant in the Coast Survey, reorganized his party for duty afloat on the coast of North Carolina, and commenced the operations of the season on the 16th of June.

Connecting with the in-shore hydrography executed in 1850, the soundings of the present year have been extended outside of the limits then reached, and into twenty-two fathoms, which depth was found about twenty miles due south from Cape Hatteras. The depth was found to be fifteen fathoms on a line carried from thence southward and westward to an offing thirteen miles due south from South Portsmouth, Ocracoke inlet. Broad off from the coast of North Carolina, and within the limit just described, which stretches about thirty-five miles in a direction generally parallel with the coast, the hydrographic survey was completed in the early part of August.

The results furnished by this party, regarding the oppressiveness of the weather and the general character of the season, are highly creditable to the energy of the chief and to the officers engaged with him in the execution of their arduous duties. These are shown in the following statistics of the work: 761 nautical miles were run in sounding, and 5,681 soundings were taken, with numerous specimens of the bottom, in from two to twenty-two fathoms. The number of angles taken by theodolites for hydrographic positions was 1,475, and the number by sextants 761. Twenty-one high tides and twenty-six low tides were observed while the work was in progress, and one thousand and seventy-five (1,075) observations were recorded.

On the character of this portion of the coast, Lieut. Comg. Almy remarks: "Except Hatteras shoals, this is a bold coast, much more so than the coast of Virginia; eleven and twelve fathoms water are carried within five miles of the land. After striking fourteen and fifteen fathoms these soundings continue out for some distance, and the depth increases more gradually. Off Ocracoke light-house, at a distance of thirteen nautical miles from the land, there are fifteen fathoms water; and off Hatteras light-house, at a distance of fourteen nautical miles due south from it, there are twenty-two fathoms of water."

Lieut. Comg. Almy has since re-examined soundings in the vicinity of Cape Henry, and completed the hydrography of Tangier sound, as mentioned under Section III.

The chart of off-shore soundings, from Cape Henry southward to the Virginia boundary, scale $\frac{1}{20000}$, has been completed by Lieut. Comg. Almy, and is now deposited in the archives.

GULF STREAM.

Instructions were given to the several parties fitting out at the north and going to the sections on the Gulf of Mexico, to make observations connected with the Gulf Stream and off-shore soundings.

The only party which succeeded in executing these instructions was that of Commander B. F. Sands, U. S. N., assistant in the Coast Survey, who sounded in about twenty-three fathoms upon the in-shore bed, with moderate slope from off Cape Fear to the mouth of Savannah river, and from thence, putting back for repairs, to Cape Cañaveral. The results, though they appear of no special value in regard to the Gulf Stream, will serve in filling up the off-shore charts. They show, too, a result in reference to currents which is of interest, namely, a northerly-setting current of from seven-tenths of a knot per hour to one and four-tenths of a knot along the coast, between Cape Fear and Cape Cañaveral. The region sounded over is on the range just inside of that occupied by the inner warm band, inside of the cold wall, represented on the chart of the Gulf Stream accompanying my report of 1854.

STATISTICS.

	Miles.	Casts of the lead.
Line of soundings inside of inner cold band........................	475	137

SECTION V.

FROM CAPE FEAR TO THE ST. MARY'S RIVER, INCLUDING PART OF THE COAST OF NORTH CAROLINA, SOUTH CAROLINA, AND GEORGIA.—(SKETCH E, No. 17.)

Eight parties have been engaged upon the coast of this section during the past season, namely: one astronomical party; two triangulation parties; two combined triangulation and topographical; one topographical, and two hydrographic parties; and the progress has been proportionately considerable.

The triangulation and topography of the very difficult region just south of the Cape Fear has advanced a step; additional work has been done in Georgetown harbor. The triangulation between Charleston and Savannah has extended to the Hunting islands, and the entire ocean shore hydrography, from Charleston harbor to Tybee entrance, inclusive, has been completed. The shores of St. Helena sound have been surveyed, and the hydrography of the sound and of Port Royal entrance has been completed.

North Edisto entrance has been resounded, and South Edisto river surveyed. Sapelo entrance has been triangulated. St. Simon's entrance and Turtle and Brunswick rivers have been triangulated and sounded out.

There remain only Wassaw, Ossabaw, and St. Catherine's inlets, on the coast of Georgia, which have not been touched by the survey; but the operations on the whole range of coast, from the Savannah river to the St. Mary's, are nearly prepared for the general system of working applicable there. This general system was explained in my report of last year, and I need not therefore repeat it now. The operations necessary to complete the surveys of the harbors and inlets referred to, on the coast of Georgia, will be completed, and others will be commenced this year. In South Carolina the triangulation and topography will be carried south towards the Savannah river, and north towards Bull's bay; and the hydrography will be finished northward from Bull's bay towards Cape Roman, working continuously northward from Charleston to Winyah bay and Georgetown harbor.

The triangulation and topography of the northern end of the section will be brought southward towards the North Carolina line.

Drawings of the following maps, charts, and sketches have been completed during the year: Georgetown harbor and Winyah bay, preliminary chart, (additions,) $\frac{1}{40000}$; Maffitt's channel, (comparative chart, 1852 to 1856,) $\frac{1}{10000}$; Charleston bar, (comparative, 1850 to 1855,) $\frac{1}{10000}$; Port Royal entrance and Beaufort harbor, $\frac{1}{60000}$; Savannah river, to the head of Argyle island, $\frac{1}{40000}$; and Romerly marshes, $\frac{1}{10000}$. The following have been engraved, or are in progress: Winyah bay and Georgetown harbor, (preliminary;) Maffitt's channel, (comparative;) Port Royal entrance; Romerly marshes and Savannah river, (preliminary.)

Astronomical and telegraphic observations and determination of magnetic elements.—At the close of the telegraphic operations, already noticed under the preceding section, the parties in the immediate charge of Assistant George W. Dean, and under the general direction of Dr. B. A. Gould, jr., were transferred to the line connecting Macon, Ga., with Montgomery, Ala.

Sub-Assistant Edward Goodfellow early in March occupied a station at the former place, while Mr. Dean occupied one at the latter. The station at Montgomery had been previously arranged with great judgment by Thomas McDonnell, Esq., artificer in the survey.

Between the 23d of March and 8th of April, star signals had been successfully exchanged by the parties on four nights, observations being also made during the interval for latitude at the Montgomery station.

I personally visited the parties in this section while they were engaged at Macon and Montgomery, and took part in the experiments in progress at Montgomery. The modes adopted in carrying out the previously arranged plan for the observations were entirely satisfactory.

No opportunity having presented since the year 1852, the occasion was taken during my transient stay at that station for redetermining the personal equation between Assistant Dean and myself.

On the 10th of April Mr. Goodfellow arrived at Montgomery, and the requisite observations having been made for personal equation between the two observers, Mr. Dean returned to the station at Macon. The subsequent operations were favored by circumstances of the weather which immediately followed, so that satisfactory exchanges of star signals were secured on four separate nights, between the 12th and 24th of the month, closing the work for the season at these two stations.

For local time and instrumental corrections, three hundred and thirty observations were made at Macon, exclusive of fifty-seven observations for equatorial intervals of the transit wires. At Montgomery, two hundred and seventy-five observations were made for time and correction of instruments, with sixty others for equatorial intervals.

The determinations for difference of longitude consisted of exchanges of signals upon two hundred stars on eight nights, between March 23 and April 24.

Observations upon an average of twenty-one stars were used in determining the personal equation between Mr. Dean and Mr. Goodfellow, and the same number for that between Mr. Dean and myself.

For latitude, one hundred and eighty observations were made by Assistant Dean, at Montgomery, with the zenith telescope, C. S. No. 5, upon forty sets of stars selected from the Greenwich Twelve-Year and British Association Catalogues. The value of the micrometer was obtained from one hundred and seventy-five observations upon Polaris near its western elongation, and the usual observations were made for the value of the level scale.

Mr. Dean determined also the magnetic declination, dip, and intensity, at a station near the State House in Montgomery, making one hundred and eighty observations for the magnetic declination on four days, and two complete sets for intensity and moment of inertia on two days, with the declinometer D. No. 22, (C. S. No. 1.) The dip of the magnetic needle was obtained from three complete sets with a ten-inch dip-circle, (C. S. No. 4.)

A meridian line of nearly a mile in length was established by Assistant Dean at Montgomery, the termini of which were permanently marked with marble posts sunk two and a half feet into the ground. The tops of the posts, which project a few inches above the ground, were inscribed with the letters U. S. C. S. The southern terminus of this meridian is in the Capitol square, and about twenty-five yards from the northeast corner of the State House, the northern extremity being near the east side of the Wetumpka road, and upon the property of Mr. W. M. Peters. Meteorological observations were as usual recorded at the stations by the aids of the parties, Mr. J. H. Toomer, Mr. McLane Tilton, and Mr. James Searles, who also read off the chronographic sheets upon which the observations for local time and instrumental corrections were recorded.

Experiments were conducted during the progress of the campaign in this section, and its connection with the stations in Section IV, for determining the velocity of the galvanic current, by using batteries of different intensities, varying from ten to forty Grove cups at each station.

Special mention is made, in the report of Assistant Dean, of the courtesies extended to him by the gentlemen severally connected with the lines of telegraph used in his operations of the season, and by others, in affording ample facilities and accommodation in transporting the instruments over the roads respectively under their charge. Prominent among those referred to as worthily entitled to the thanks of the Survey for important aid so rendered, are: Messrs. J. C. Butler and W. W. Heiss, superintendents upon the Washington and New Orleans Telegraph Line; R. R. Cuyler, Esq., president of the Georgia Central Railroad Company; and C. T. Pollard, Esq., president of the Montgomery and West Point Railroad Company.

Assistant Dean returned to Washington early in May, and made immediate preparation for continuing the work of the primary triangulation in Section I, in which he was unremittingly engaged until late in the autumn.

The longitude parties were visited by Dr. Gould in April, and under his direction a station was established in the public square of Mobile, and a site selected at New Orleans for occupation during the present winter.

The records and computations resulting from the observations made at Columbia, Macon, and Montgomery, for latitude and magnetic elements, have been received from Assistant Dean.

Primary and secondary triangulation in South Carolina.—The primary and secondary triangulations of the coast southward and westward from North Edisto river have been continued by the party of Assistant C. O. Boutelle.

Operations were begun in the reoccupation of the station New Cut, on the north shore of Wadmelaw island. The primary work was carried over Edisto and Fenwick islands, and now includes the upper part of St. Helena sound. The secondary triangulation was extended from South Edisto river over Fenwick and Hutchinson islands, and quite over the waters of St. Helena sound and to the Hunting islands.

Lieutenant Rufus Saxton, U. S. A., assistant, was associated with Assistant Boutelle in the work of the season in this section.

A reconnaissance for continuing the triangulation was made as far as Port Royal entrance, to facilitate the operations projected for the ensuing season, for which active preparations are now in progress, under the direction of Assistant Boutelle. These contemplate the prosecution of the triangulation towards Savannah, and also north and east from Charleston towards Bull's bay. Mr. F. P. Webber was attached to the party as aid.

During the progress of the operations conducted by Mr. Boutelle, points were furnished by him for the use of the hydrographic party of Lieut. Comg. Maffitt, the labors of which will be presently noticed.

The following statistics are returned in the report of the season's work of primary and secondary triangulation:

"Twenty-five stations in all were occupied between the 12th of February and 4th of May, and at these two hundred and twenty-one angles were measured upon two hundred and twenty-six objects by one thousand eight hundred and twenty-nine observations."

The schooner Guthrie, intended for the transportation of instruments and the equipage of the party, was disabled on the coast of New Jersey shortly after her departure from New York, causing much delay in the commencement of work. After the necessary transfer, accommodations were furnished for the party by Assistant Seib, in the schooner Wave, which service is duly acknowledged in the general report of Assistant Boutelle.

A volume, containing the computed results of observations made for latitude at Allston station, has been sent to the office by Assistant Boutelle.

Secondary triangulation and topography, coast of North Carolina, south of Cape Fear river.—(*Sketch* No. 17.)—The means referred to in my last season's report, in connection with the work south of Cape Fear, have been successfully applied in extending the secondary triangulation and topography of the coast as far as Lockwood's Folly. This was accomplished by the party of Assistant C. P. Bolles. The approaches to Cape Fear and to Lockwood's Folly inlet are included in the triangulation.

Sub-Assistant G. H. Bagwell assisted Mr. Bolles in joint work throughout the season in this section, and at the close of operations joined the party of Assistant Blunt in Section II.

Nineteen stations were occupied by Assistant Bolles in the triangulation south of Cape Fear, and the intersections included the measurement of seventy-five angles.

Arrangements are now in progress for continuing the work southward to the boundary line of North Carolina.

Triangulation of St. Simon's sound and Brunswick harbor, Georgia.—This work, which is mentioned in my last annual report as having been commenced, has been completed within the present season by the party of Assistant A. W. Longfellow.

The schooner Meredith, with the instruments of the party, arrived at Brunswick on the 21st of December, and, after a few days spent in necessary repairs, the triangulation was resumed by Mr. Longfellow in St. Simon's sound. Measurements were completed at the close of April, of triangles extending from the shores of St. Simon's and Jekyl islands, thirteen miles through the sound, and up Turtle river to Blythe island, and including the lateral channels to Brunswick city and Hamilton, which comprise about twenty miles of water passage.

During the progress of the work, points requisite for the execution of the hydrography were furnished to the party of Lieut. Comg. Trenchard.

Assistant Longfellow remarks, in reference to the character of the season: "Bad weather, which set in at the commencement of the work, continued almost the whole season along this part of the Atlantic coast, making the most severe and stormy winter known on the coast of Georgia for a period of, probably, thirty years. The storms recurred at such frequent intervals that the atmosphere was kept in constant commotion. For triangulation purposes, not an hour of continuous seeing was afforded throughout the season."

In completing the work, one hundred and eighteen angles were determined by five hundred and eighty-six observations, direct and reverse. Three thousand four hundred and ninety-nine repetitions were made with the 6-inch Brunner theodolite, C. S. No. 67.

The lines of sight, passing alternately over marsh and water, opposed great difficulties in the determination of angles, owing to the unequal refraction.

The triangle sides were computed as the observations were made, and duplicates of the field notes, containing such and other data, after being compared with the originals, will be deposited in the archives.

Assistant Longfellow has furnished the computations of his work executed in the previous season at the Romerly marshes.

Triangulation of Doboy inlet and Sapelo sound, Georgia.—After completing the duty to be hereafter noticed, (under the head of Section VI,) a thorough reconnaissance of this vicinity was made in April by Lieutenant A. W. Evans, U. S. A., assistant in the Coast Survey, as preliminary to the triangulation. The following extract from his report states in detail the subsequent operations of his party:

"A base site of rather more than a mile in length was selected at the north end of Sapelo island, the greater part of which was through a growth of young live-oak, occupying my party about five days in opening the line. The actual measurement of the preliminary base (1,700.7 metres) occupied portions of six days. The broad expanse of marshes and rivers between the islands and the main land of this part of Georgia presented great facilities for triangulation, only a few of the lines requiring any cutting. In the work of triangulation, nine stations of the first order, and thirty-seven of the second, were erected. Two hundred and eighty-one angles were measured at thirteen stations, by two thousand one hundred and four observations with the theodolite."

"The work can be readily extended, from bases now established, over Black-beard island, and the narrows between that and Sapelo island, to Cabarita entrance, so as to furnish points on the outside of these islands for hydrographic purposes, northward to St. Catherine's, or southward to Doboy sound; and for the extension of inside work, triangles of from four to five miles on a side can be readily obtained."

The work at Sapelo sound was begun on the 15th of April, and completed on the 25th of June, when Lieutenant Evans sailed for Savannah. From that port he despatched the schooner "Hassler" to New York, where she arrived safely on the 19th of July, and, after refitting, the vessel and party were employed during the remainder of the season in the prosecution of secondary triangulation, as mentioned under Section I.

Mr. F. M. McIver joined the party of Lieutenant Evans on the 28th of April, and served with it as aid during the continuance of operations in Section V.

Topography of Dawho river and South Edisto, and of St. Helena sound, South Carolina.—The party of Assistant John Seib was organized early in December, and left Baltimore on the 17th of that month, in the schooner Wave; but the vessel, after being detained by bad weather in Chesapeake bay, was unfortunately disabled in a storm off the Fryingpan shoals, and with much labor and difficulty was got into Charleston on the 3d of January. Indispensable repairs occupied a month, during which Mr. Seib and the aid, Mr. W. H. Dennis, employed themselves in inking the topographical sheets of the previous season.

The Wave, on leaving Charleston, afforded transportation for the triangulation party and camp equipage of Assistant Boutelle.

Mr. Seib commenced a topographical sheet, showing the entrance to the South Edisto river, and subsequently of the Dawho river, commencing at the Dawho ferry signal. The shore-line and topography of both shores were completed from its junction with the South Edisto and Pon Pon rivers to within about five miles of its mouth, where the sheet joins with the last season's work of Mr. Seib on Edisto island, and with a previous topographical survey by Assistant Wise.

"The Dawho river is very narrow and crooked, though less than twelve feet at low water was nowhere found in the middle of the channel. The numerous dams and watercourses on Jehossee island made the work slow in progress, as did also the muddy shores of the river, and the many creeks intersecting the marshes on and opposite to Edisto island."

On the 5th of April Assistant Seib moved his party to St. Helena sound, and expeditiously completed the plane-table survey of its shore-line, including the mouths of the Ashepoo, Combahee, and Morgan rivers, and the outer coast-line, extending from the Hunting islands southward and westward nearly to the entrance of Port Royal sound. These data were promptly furnished to the hydrographic party of Lieut. Comg. Maffitt.

The topographical work of Assistant Seib in this section, commenced within the present season, is embraced in three sheets, which now contain, respectively, the upper part of the South Edisto and part of the Dawho river; the lower part of Edisto island and entrance to South Edisto river; and St. Helena sound, with the mouths of its dependencies and the ocean shore southward of the entrance.

The work required in filling the sheets will hereafter be resumed for completion. Assistant Seib reports as the statistic results of the season:

Miles of shore-line surveyed	103
Miles of roads surveyed	17½
Area, in square miles	20

At the close of the operations of the party, Mr. Dennis was assigned to detached duty, and executed, under the general direction of Assistant Seib, a resurvey of Rabbit and Hare islands, in Georgetown harbor, South Carolina, tracing also the shore-line from signal "*Sin*" to the light-house. The result was furnished to Lieut. Comg. Maffitt for purposes connected with the issue of a new edition of the preliminary chart of Winyah bay and Georgetown harbor.

The schooner Wave reached Baltimore on the 17th of May, and Assistant Seib shortly afterwards resumed topographical work in Section III. He commends specially the services of Mr. Dennis, the aid in his party.

Topography of St. Simon's sound.—Assistant Longfellow took up, on the 30th of April, the topography of St. Simon's sound, following his own triangulation, the completion of which has been already noticed. Plane-table operations were carried on until the middle of May, and then discontinued in consequence of adverse weather. The two topographical sheets commenced by Mr. Longfellow contain both shores of the entrance to St. Simon's sound, and, generally, both shores from the entrance, up Turtle river to Blythe island, the shore-line left for execution in the coming season being at points most remote from the main channel. This will be completed by the party at an early day, under instructions which have been already issued.

The topographical statistics comprise thirty-one miles of shore-line. Tracings of the sheets were furnished by Mr. Longfellow for the use of the hydrographic party.

In the middle of April I used the schooner Meredith to visit Fernandina, for a review of the operations of the parties there.

Mr. N. S. Finney was attached as aid to the party employed on St. Simon's sound and Brunswick harbor.

With reference to facilities afforded in the prosecution of the survey in the vicinity, Assistant Longfellow mentions for special acknowledgment the courtesies shown and assistance afforded by Colonel Charles L. Schlatter, chief engineer of the Brunswick and Florida railroad, and by Colonel Thomas Boncke and Butler King, jr., Esq. I must return my thanks to Mr. Finigan, contractor on the air-line railroad, for facilities kindly furnished by him at Fernandina.

The schooner Meredith was despatched to Portland, and has since been in the service of Mr. Longfellow's topographical party in Portland harbor. This party is now about making preparations for returning to complete the work on the coast of Georgia.

One topographical sheet of work executed by Assistant R. M. Bache in this section, and two by Sub-Assistant S. A. Wainwright, have been inked within the season and deposited in the archives.

Hydrography between Charleston and Savannah.—The in-shore hydrography of the coast of South Carolina, together with soundings in special localities between Charleston harbor and the entrance to Savannah river, has been completed within the past surveying season by the party of Lieut. Comg. J. N. Maffitt, U. S. N., assistant in the Coast Survey.

Three surveying vessels were assigned for the accomplishment of this duty.

Maffitt's channel, in Charleston harbor, was again examined, and a copy of the resulting chart of the present year furnished to the office in April.

Lieut. Comg. Maffitt, with the schooners Bancroft and Crawford, also completed the necessary supplementary hydrography at the entrance of Port Royal bay and Broad and Beaufort rivers, together with the hydrography and requisite shore-line of St. Helena bar and sound, and the in-shore soundings between the coast and Martin's Industry.

Under Lieut. Comg. Maffitt's direction, Lieut. Hunter Davidson, in the schooner Gallatin, executed the in-shore soundings, commencing two miles northeast of the mouth of North Edisto river, South Carolina, referred to in my report of last year as the limit then reached in the operations of Lieut. Simpson. The hydrography was continued southward by Lieut. Davidson, and connects with the work at St. Helena bar, already mentioned as completed under the direction of Lieut. Comg. Maffitt.

Lieut. Davidson completed also the hydrography of the bar and harbor of South Edisto river, and made a reconnaissance at the entrance of the North Edisto, to ascertain the changes which had occurred since the original survey in 1851.

Supplementary soundings were made in the vicinity of the bar of Georgetown harbor and to the northward and eastward of Rattlesnake shoal. The data last referred to will be presented as early as practicable in a new edition of the chart of Charleston harbor, first issued in 1855.

The hydrographic work having been commenced in December, the general severity of the winter of 1855–'56 offered serious obstacles to the progress of the surveying party afloat in this section; and the return of statistics, under these known circumstances, showing as it does, more than the usual amount of work completed, as compared with the average of past seasons for this and other sections, is highly creditable to the zeal evinced by the hydrographic chief and to the energy of the officers associated with him.

Observations of tides and currents were made during the progress of the hydrography.

Four permanent and two temporary tidal stations were establishsd at St. Helena bar and South Edisto river. Occasional tidal observations were made also at Fort Sumter and at South Wharf, in Georgetown harbor.

Lieut. Comg. Maffitt subsequently (in June) continued the hydrography of James river, the statistics of which are exclusive of the following summary of work completed on the coast of South Carolina within the season:

Whole number of soundings	107,855
Whole number of angles	9,527
Miles run in sounding	4,801
Specimens of bottom taken from different localities	65
Current stations	7
Permanent tidal stations	4
Temporary tidal stations	4

Full records of the hydrographic operation have been returned, in duplicate, and deposited in the archives at the office.

Charts of the resurvey of Maffitt's channel, scale $\frac{1}{5000}$; entrance to Charleston harbor, $\frac{1}{5000}$; North channel; Georgetown bar; North Edisto bar; and hydrographic reconnaissance of Port Royal entrance and bay, $\frac{1}{20000}$, have been received from Lieut. Comg. Maffitt, and recorded with the archives.

On the night of December 22, 1855, a fire occurred at Beaufort, S. C., which threatened destruction to the town. By the exertions of Lieut. Braine and the officers and crew of the schooner Bancroft, in common with others, the danger was happily arrested. The thanks of the citizens were tendered, through Lieut. Comg. Maffitt, to the officers who so promptly assisted in the emergency.

Hydrography of Brunswick harbor and St. Simon's sound, Georgia.—Lieut. Comg. Stephen D. Trenchard, U. S. N., assistant in the Coast Survey, in charge of the schooner Bowditch, commenced the survey of Brunswick harbor on the 12th of February, and, working towards the entrance of the sound, reached St. Simon's bar on the 9th of June, having completed the hydrography of the sound and of Brunswick and Turtle rivers.

One permanent and five temporary tidal stations were established; at the first, night and day tides being observed for seventy-one days. The results thus obtained were forwarded to the Coast Survey Office.

The permanent station was established near the north point of Jekyl island, within the entrance of St. Simon's sound.

The mean rise and fall of ordinary tides, as given by the observations, is 6.8 feet, and of spring tides 8.3 feet.

In connection also with the hydrographic operations, ten current stations were occupied.

"The greatest velocity observed was off Jekyl island, near the tidal station, during full moon, the current there running from five to six miles per hour, though its ordinary rate is from two and a half to three miles.

"High water occurs at Brunswick twenty-four minutes later than at St. Simon's entrance, and low water twenty-eight minutes later."

The following are the statistics of the hydrographic work executed by this party:

Miles run in soundings	598
Total number of soundings	28,200
Theodolite angles observed	1,856
Sextant angles observed	318

Remarks relative to the capacity of the bar and channel of St. Simon's are contained in the report of Lieut. Comg. Trenchard, given in the Appendix No. 49.

His suggestions in regard to the placing of buoys to facilitate the navigation of the sound have been presented to the notice of the Light-house Board in my communication to the Department, contained in Appendix No. 81.

Two of the hydrographic sheets of Brunswick harbor, scale $\frac{1}{20000}$, have been received from Lieut. Comg. Trenchard, and deposited in the archives. He has returned also four volumes containing soundings, and two of angles recorded in the work of the season, together with the results of observations made on currents in St. John's river. (Section VI.)

Tidal observations.—The continuous series of observations attempted at Castle Pinckney having become broken by the concurrence of adverse circumstances, alluded to in my last yearly report, a self-registering tide-gauge was established finally at the wharf of the new custom-house in Charleston, S. C., and it is now in successful operation, under the charge of Mr. W. R. Herron.

Observations of tides for short periods were also made in connection with the hydrographic work at Stono river, Beaufort, and Port Royal, S. C., and at Jekyl island and Doboy inlet, Ga.

Suggestions made by Lieut. Comg. T. A. Craven, U. S. N., assistant in the Coast Survey, in regard to the expediency of distinguishing by local designation the outer buoys on the Atlantic coast southward from Savannah, were communicated to the Department in April, for the information of the Light-house Board. The extract from his letter having reference thereto is given in Appendix No. 80.

SECTION VI.

FROM THE ST. MARY'S RIVER TO ST. JOSEPH'S BAY, COAST OF FLORIDA, AND INCLUDING THE FLORIDA REEFS AND KEYS.—(SKETCH F, Nos. 25, 26.)

Notwithstanding the Indian hostilities, which deranged in a degree the plans for working on the Florida main in this section, the progress has been good. The triangulation of the Florida keys and reef is quite two-thirds done; the gap between Sister key and Key Rodriguez, of about fifty miles, will be filled in two or three seasons, giving then a continuous chain from Virginia key, near Cape Florida, to the Marquesas, inclusive.

The topography has kept within a season's work of the triangulation, and the marking of the keys connected with Key West has accompanied it. The hydrography has kept close upon the topography, extending now from Key Biscayne bay to the vicinity of Key Rodriguez, and from Key West to Loggerhead key.

The result of examinations made of the soil from Key Biscayne, and from the shores and prairie of Cape Sable, by Professor Wolcott Gibbs, of the Free Academy, New York, is given in the Appendix No. 64. No silicious sand occurring near Cape Sable, or soil or rocks which would yield it, the remark in regard to its amount is of considerable interest in reference to the currents of adjacent parts of the Florida coast.

In the following pages are given the details of the operations in this section.

1. Of the observations for latitude at Fernandina.
2. The completion of the triangulation of St. Mary's entrance and of Fernandina harbor.
3. The measurement of a base of verification on St. John's river, near Jacksonville.
4. Of the triangulation of the keys and reef from Loggerhead key to Horse-Shoe key and Middle Summerland.

5. The prolongation of this work to Sister key.

6. The erection of signals intended for the triangulation connecting Cape Sable with the keys.

7. The topographical survey and marking of Loggerhead, Middle Summerland, Cudjoe, and Gopher keys, with others of less magnitude.

8. The topography of Johnston's and Sawyer's keys, and of thirty-five other smaller keys.

9. The completion of the topography of the St. John's river to Jacksonville.

10. The hydrography of the reef from Grecian shoal to French reef, and from Loggerhead key westward to the Eastern Sambo.

11. The completion of the hydrography of St. Mary's entrance and Fernandina harbor.

12. Deep-sea soundings in the Gulf of Mexico.

13. Tidal and current operations in the St. John's, for the Engineer Department.

14. The preparation of a beacon for the Elbow, Florida reef.

The following drawings have been completed during the year: St. John's river, $\frac{1}{25000}$; Legaré anchorage, $\frac{1}{20000}$; and Tampa bay, $\frac{1}{120000}$, Florida reefs, $\frac{1}{200000}$, (preliminary chart,) and Florida reefs, $\frac{1}{80000}$, (finished map,) are in progress.

The engraving of the sketch of beacons on Florida reefs, Legaré anchorage, $\frac{1}{20000}$, (reconnaissance;) and Tampa bay, $\frac{1}{120000}$, (reconnaissance,) was executed within the year.

Astronomical observations for latitude.—On being detached from the party engaged in the determination of telegraphic differences of longitude, as noticed under Sections IV and V, Sub-Assistant Edward Goodfellow proceeded, under my instructions, to occupy for latitude a station at Fernandina, Florida.

"An observatory was built and observations begun on the 19th of May. The instruments used were the zenith telescope No. 5, and transit No. 8, of the Coast Survey. Single blocks of stone of sufficient size not being procurable, the first named was mounted upon three, and the second upon two wooden posts, each five feet nine inches in length, and twelve by eight inches in section. These, on being sunk in the sand to a depth of nearly three feet, afforded a steady foundation for the instruments.

"For latitude, one hundred and ninety-nine observations were made on sixty-four stars, arranged for observation in thirty-four pairs. The average number of observations upon a single pair was six.

"For value of micrometer, one hundred and fourteen observations, in two sets, were made upon 51 *Hev. Cephei*, at western elongation, and ninety-eight observations were taken upon a distant mark for value of level.

"The stars observed for time and instrumental correction were all selected from the Nautical Almanac. Eighty-seven observations were made for these purposes upon twelve stars.

"Sixty-three observations of the barometer and thermometer, arranged in the usual manner, were entered in the meteorological register.

"After placing the transit instrument carefully in the meridian, a meridian line about a quarter of a mile in length was established on Amelia island. The extremities of this line are marked by marble pillars nearly three feet long and five inches square. These were placed vertically in the ground, their tops, upon which were cut the letters U. S. C. S., being left on a level with the surface. Lines crossing at right-angles are also marked on the top of each pillar, through the intersections of which, on each, the meridian line passes."

The advance of the season not admitting of delay in procuring instruments suitable for making elaborate magnetic observations, the approximate magnetic bearing of the meridian line established on Amelia island was found by a common surveying transit.

Mr. McLane Tilton served as aid in the astronomical party.

The report of Sub-Assistant Goodfellow concludes with the expression of his obligations to the gentlemen connected with the Florida Railroad Company for prompt and liberal assistance in the erection of the temporary observatory, and in the prosecution of the work.

Mr. Goodfellow has sent to the office the records of his observations. At the close of August he joined my party, and assisted in its operations at the station (Mount Desert, Maine,) in Section I.

Triangulation of St. Mary's river, Georgia, and Fernandina harbor, Florida.—Lieut. A. W. Evans, U. S. A., assistant in the Coast Survey, with a party in the schooner Hassler, resumed operations in Cumberland sound, on the 21st of December, and having completed his reconnaissance, the nature of which is detailed in my last annual report, the necessary signals were erected for executing the triangulation. The work was carried steadily forward, until its completion, on the 5th of March. The connected series of triangles includes Tiger island, Cumberland sound, and Fernandina harbor, with the entrance to St. Mary's river and vicinity, as far up as the town of St. Mary's. Progress in the field-work was much retarded by the prevalence of northeasterly storms in January. Exclusive of the statistics of reconnaissance previously given, nine signals of the first, and twenty-seven of the second order were erected within the season. Eleven stations were occupied for measurements with the theodolite, and three hundred and seven angles were determined, with intersections upon fifty-three objects, by two thousand six hundred and sixty observations. The positions of sixty-three different points were accurately determined in this vicinity.

Further operations in completion of the survey at the entrance to the St. Mary's river will be noticed under the head of hydrography.

On concluding the field-work, the party of Lieut. Evans proceeded in the Hassler to the St. John's river. His service, as connected with the completion of the survey in that locality, will be now described.

Measurement of a base of verification on St. John's river, Florida.—Before closing his work of the previous year, Lieut. Evans had selected, near Jacksonville, the site for a base of verification for the triangulation of the St. John's river, the measurement of which was necessarily deferred by reason of the advance of the season. He arrived at Jacksonville, in the schooner Hassler, on the 9th of March, with the apparatus previously used in determining the length of the preliminary base at Tiger island, and, having adjusted elevating screws to the trestles and substituted a level for the boxes in lieu of the surveyor's instrument employed on that occasion, the measurement was commenced of the closing line, which had been fixed on as the upper base. The changes made in the apparatus are reported by Lieut. Evans as having greatly facilitated his further operations in execution of this duty. When almost at a loss for the want of the requisite assistance, which it was expected could have been procured at Jacksonville, he fortunately secured the services of Mr. Gustavus Würdemann, then employed under my instructions in separate duty connected with the survey of the river. In consequence of frequent rains, the execution of the work was somewhat delayed. The actual measurement occupied parts of eight different days throughout the latter part of March and beginning of April. Each bar, after adjustment, was carefully levelled, the contact being so made in every case from one terminus to the other. The measured length of the base, 1,511.67 metres, was found to agree nearly with that deduced by calculation from the triangle sides. The termini were marked on blocks of stone, fixed in position before beginning the measurement.

After completing the requisite connection of the verifying base with the triangulation of the St. John's river, Lieut. Evans proceeded, under my instructions, to Sapelo entrance, Ga. The execution of the duty assigned in that vicinity has been mentioned under Section V.

The records of observations and computations of the work executed on the St. John's have been turned in by Lieut. Evans.

Triangulation of the Florida keys.—Two parties, as in former seasons, were detailed for the continuance of the triangulation work on the main, and for its extension eastward among the keys from last year's limits. The first of these, in charge of Lieut. A. H. Seward, U. S. A., assistant in the Coast Survey, was instructed to connect the Cape Sable base with the keys lying in the vicinity of the coast to the southward and eastward. Signals were erected by the party at Cape Sable, and at stations intervening between it and Centre key, but threatened hostilities from the Florida Indians constrained him to leave the hunting grounds. The necessity for this will appear from my communication with the War Department, given in Appendix No. 72. Lieut. Seward at once transported his party to the keys, eastward of the eastern limits of the work of Sub-Assistant Rockwell, to be presently noticed. The triangulation was carried from Horse-Shoe key and Middle Summerland, eastward, to Jacob's Point, a distance of about eighteen miles. Twenty-nine signals were erected, and eighteen stations were occupied, before the first of June, when the season closed. Four thousand and seventy-one single observations were recorded in determining the angles measured. The triangulation covers an area of about one hundred and eight square miles.

Lieut. Seward, on returning to the north, was attached to the party of Assistant Edmund Blunt, then engaged in the triangulation of Hudson river, as mentioned under Section II.

Sub-Assistant John Rockwell, succeeding before the close of the previous season to the charge of the party of Lieutenant (now Captain) James Totten, U. S. A., commenced his triangulation at the eastern (Pt. Dora) and northern limits reached in that year.

The work was carried northward, from Newfound harbor to Content and Harbor key, and eastward, from Pt. Dora to Little Pine key, at which it forms, with Johnson's key on the north, and Middle Summerland on the south, a junction with the triangulation of Lieut. Seward, already noticed.

In pursuance of arrangements made at the beginning of the season, the charge of the party in the schooner Petrel was transferred to Sub-Assistant J. A. Sullivan, who had been relieved from duty in Section IX for this purpose.

Mr. Sullivan arrived at Key West early in April, and conducted the operations of the party until the close of the season. Having completed the observations commenced by Mr. Rockwell, at stations Johnston's and Budd, he occupied and completed measurements of angles from the stations Content, Harbor, Driftwood, and Soldier Crab, and verified the angle made at Newfound harbor, with stations adjacent to it on the eastward. Nineteen stations in all were occupied, from which five thousand seven hundred and seventy-six observations were made upon twenty-four points in the determination of eighty-four angles. The area included in this triangulation is about two hundred and forty square miles.

On reaching the office, Mr. Sullivan was assigned to topographical duty in Section II.

Mr. S. J. Hough served as aid to the party engaged in this section, and is specially commended in the reports of Sub-Assistants Rockwell and Sullivan.

It was arranged that a third party, that of Lieutenant A. W. Evans, U. S. A., should take up the triangulation of the Florida main, near Cape Sable, proceeding towards Shark river; but the interruption already referred to rendered a change of plans expedient, and it was made accordingly.

The recorded observations of the joint work of Sub-Assistants Rockwell and Sullivan, with their computations, have been deposited in the office.

Topography of Florida keys.—Two parties also, as heretofore, have been engaged in the continued survey, for the General Land Office, of keys lying northward and eastward from Key West.

The party of Sub-Assistant C. T. Iardella, in the schooner Agassiz, commenced with the plane-table at Sugar Loaf, on the 1st of January, and in that vicinity completed the topography of Loggerhead key, Middle Summerland key, Cudjoe key, and Gopher key, together with the several smaller patches of keys, to which local names have not yet been given. All the firm land ound on the several keys included in his plane-table sheet has been subdivided and marked in sections by a method stated in his report on the work, which will be found in detail in Appendix No. 52.

The statistics of the work of Mr. Iardella are as follows:

Miles of shore-line of keys traced	210
Square miles of firm land surveyed	32
Total square miles included in sheet	70

Mr. F. W. Alexander served as aid in this party.

The topographical sheet of Sub-Assistant Iardella, containing his work of the season, has been inked and turned into the office, together with two sheets of previous work by Assistant Adams.

The second topographical party, in charge of Sub-Assistant S. A. Wainwright, in the schooner Joseph Henry, proceeded at the commencement of the season for the continuation of topographical work on Key Largo; but the near approach of hostile Indians, known to have ventured beyond the coast in that vicinity, rendered it necessary to transfer the party to a greater distance from the main. Having at length selected points within the triangulation of Sub-Assistant Rockwell, Mr. Wainwright commenced in February his plane-table sheet, with the survey of Johnston's key. The work was continued until the end of April, and includes, besides that just named, Sawyer's key, and another in its vicinity, equal in size, together with thirty-five smaller keys. The firm land contained in Johnston's key was marked at the intersection of meridians with quarter-section lines by posts, as described in the report of Sub-Assistant Wainwright, a copy of which will be found in Appendix No. 52. The following statistics are presented by the topographical sheet:

Miles of shore-line surveyed of keys and banks	80
Square miles of in-line of keys surveyed	4

Mr. J. L. Tilghman served as aid in the party of Mr. Wainwright.

The topographical sheet of the present season has been inked and returned to the office by Sub-Assistant Wainwright, with two sheets of work executed in the previous season.

The schooners Agassiz and Joseph Henry were, at the close of operations for the season, laid up at Key West.

Sub-Assistant Iardella has since been engaged in topographical duty, as already stated under Section I, and is now preparing to resume work on the Florida keys.

Copies, in triplicate, of the topographical sheets, showing the results of the past surveying season, were transmitted in October, with my report to the Commissioner of the General Land Office, a copy of which is contained in Appendix No. 52.

Topography of St. John's river.—The part of the survey of this river referred to as remaining unfinished at the date of my last annual report, has been completed by Assistant A. M. Harrison. The schooner Benjamin Peirce, with the instruments and equipage of the party, arrived at Jacksonville on the 20th of December; but while lying at anchor there, the vessel received so much damage by the drifting to her berth of the steamer Seminole, which had unfortunately taken fire, as to cause a delay of several weeks in the regular operations of the season.

The topographical survey was resumed on the 14th of January, and completed by the 1st of the ensuing month. The sheet of this season comprises the city of Jacksonville and both shores of the St. John's river, extending from the city upwards to Winter's Point. Within these limits, which include an area of two and a half square miles, the topographical sheet embraces eight miles of shore-line, and ten and a half miles of roads.

The survey of the St. John's, between Mayport Mills and Winter's Point, undertaken, as already stated, at the request of the Engineer Department, is now complete; and the sheets of the previous season, inked by Assistant Harrison while repairs were in progress on the vessel of the party, have been deposited in the archives, together with that finished within the present year.

Some particulars of interest relative to the character of the river and vicinity, communicated by Assistant Harrison, will be found in Appendix No. 51.

On completing operations at the St. John's, the party was transferred to section VII.

The disaster to the steamer Seminole, before mentioned, threatened, amongst other vessels, imminent damage to the Coast Survey schooner Peirce, which was, however, happily averted by the timely and commendable energy of Mr. P. R. Hawley, the aid in Mr. Harrison's party.

The official report of Assistant Harrison on the subject is given in Appendix No. 71.

Three topographical sheets, comprising the map of St. John's river, have been put in ink within the season by Assistant Harrison, and are now registered with the archives in the Coast Survey office.

Hydrography of Florida reefs.—The soundings on the Florida reefs have been continued in two localities within the season by the party of Lieut. Comg. T. A. Craven, U. S. N., assistant in the Coast Survey, in the steamer Corwin and tender Sophia. Work was commenced on the 1st of February broad off from Key Largo, and extended from Grecian shoal southward and westward to French reef. The hydrographic sheet of this vicinity comprises the soundings requisite within an area of about sixty-four square miles. A second sheet was executed, containing soundings made between Loggerhead key and Eastern Sambo, embraced in an area of seventy-six square miles.

The hydrographic work was terminated for the season on the 1st of May, the party returning the following statistics:

Angles determined	2,387
Miles run in sounding	1,287
Total number of soundings	58,200
Greatest depth sounded, (fathoms)	50
Least depth sounded, (fathom)	1
Tidal stations	2

Reference has been already made, under Section V, to the suggestions communicated to me by Lieut. Comg. Craven, in regard to designations for the coast buoys south of the entrance to Savannah river. The subject was formally presented for the consideration of the Light-house Board in my communication to the Department, which will be found in the Appendix, (No. 80.)

Since his return from this section, Lieut. Comg. Craven has been engaged in prosecuting, with accustomed energy, the hydrography necessary to complete the resurvey of New York harbor, as noticed under Section II.

A hydrographic sheet of Doboy bar and sound, (Section V,) $\frac{1}{20000}$, based on the reconnaissance made in the previous season by Lieut. Comg. Craven, has been returned to the office, together with seven volumes of the soundings on Florida reef, and sixteen specimens of sea bottom, taken from various localities during the progress of the work.

Hydrography of St. Mary's river and Cumberland sound.—The supplementary hydrography requisite for the chart of the entrance to St. Mary's river and Fernandina harbor has been completed by the party of Lieut. Comg. Trenchard. Commencing on the 11th of June, St. Mary's bar was re-examined with great care, the results of this work being compared with those obtained in the hydrographic reconnaissance made by that officer in the previous season.

The soundings were continued up Amelia river to a point half a mile above the railroad wharf, and also into Cumberland sound, extending a mile from the entrance, and up the St. Mary's river, in which they were terminated half a mile above the town of St. Mary's.

Four current stations were occupied, and three tide-gauges kept in temporary use for the reduction of the soundings.

The mean rise and fall of the tides, as derived from observations conducted by Lieut. Comg. Trenchard, at the entrance to St. Mary's river, is five feet and seven-tenths, and of spring tides about seven feet. He states that the highest tides are found to occur during the months of August, September, and October, when the winds prevail fresh from the northeast, the lowest being coincident with the full and change of the moon, with the wind from the westward.

The following statistics are contained in the report of Lieut. Comg. Trenchard:

Miles run in sounding	100
Total number of soundings	7,000
Theodolite angles observed	260
Sextant angles observed	300

On the completion of the hydrographic survey of the St. Mary's, at the close of June, the party returned to New York in the schooner Bowditch, and the vessel was soon afterwards transferred to the topographical party of Sub-Assistant Sullivan. Lieut. Comg. Trenchard was subsequently assigned, for the remainder of the surveying season, to the command of the steamer Vixen, and engaged, after finishing his office-work, in the hydrography of Casco bay, noticed under Section I.

Lieut. Comg. Trenchard has sent for deposit in the archives a sheet of St. Mary's bar and Fernandina harbor, scale $\frac{1}{20000}$; also three sheets containing the results of his hydrographic survey of St. John's river, scale $\frac{1}{10000}$. The soundings on the latter are comprised between Mayport Mills, near the entrance, and Jacksonville. The hydrographic sheets are accompanied by a chart exhibiting the stations occupied by his party for current observations made at the bar of the St. John's.

The records of soundings made in executing the hydrography of St. John's river, comprised in seven volumes, have been placed in the archives of the Section.

Deep-sea soundings.—On the outward passage of the steamer Walker, Commander B. F. Sands, U. S. N., assistant in the Coast Survey, to the station allotted for the service of his party in Section VIII, a line of soundings was carried, with a single interruption in consequence of rough weather, from Key West (northwest passage) to the delta of the Mississippi. Bottom was found on this line in 336 fathoms with 1,250 fathoms of line; but the effort made to carry soundings throughout proved unsuccessful, although several casts were made with 1,290 fathoms of line out.

Commander Sands, on returning from his station, carried a line of continuous soundings from Chandeleur sound to the northwest passage of Key West harbor, further reference to which will be made in the notice of the hydrographic operations conducted by him in Section VIII.

Tidal observations.—A self-registering tide-gauge was established in February by Mr. Gustavus Würdemann at Fort Clinch, at St. Mary's entrance; after which he proceeded to St. John's river, Florida, and repeated the current and tidal observations made by the hydrographic party there engaged in the preceding year. Four stations were occupied simultaneously in the river, and three stations at the mouth and on the bar.

The gauge at Fort Clinch will be kept in operation as one of the permanent stations.

Records of the observations made at St. John's river have been deposited in the office by Mr. Würdemann.

Preparation of a beacon for the Elbow, Florida reef.—An iron beacon for "The Elbow" was procured in New London, Connecticut, and from thence shipped by the General Disbursing Agent, Samuel Hein, Esq., to Key West, on the 17th of July. Sub-Assistant Rockwell having left this section, after completing arrangements for the erection of the beacon, it was consigned to Lieutenant M. C. Watkins, U. S. N., light-house inspector at Key West.

SECTION VII.

FROM ST. JOSEPH'S BAY TO MOBILE BAY, INCLUDING PART OF THE COAST OF FLORIDA AND ALABAMA.

(SKETCH G, Nos. 30—32.)

This is only the second year for which an appropriation has been granted for this difficult section, thus necessarily much behind the others in its progress. Five parties have been employed during the season, namely: two triangulation, two topographical, and one hydrographic party, and a combined triangulation and topographical party was also occupied here during part of the season. The means available, however, did not permit each of the parties to have a separate vessel for transportation, and accordingly their progress was less than it would have been under more favorable circumstances. The work accomplished is detailed under the following heads:

1. The triangulation of Cedar keys and approaches.
2. The triangulation of St. Mark's river and approaches.
3. The triangulation of Apalachicola harbor, and its approaches by the eastern and western passes.
4. The triangulation of part of Pensacola harbor and approaches.

5, 6, 7, 8. The corresponding topographical work near Cedar keys, of St. Mark's, Apalachicola, and Pensacola.

9. The hydrography of the approaches to Cedar keys and of Waccasassa bay and Crystal river offing.
10. The hydrography of St. Mark's river and approaches.
11. The completion of the hydrography of St. Andrew's bay.

A finished chart of Cedar keys, $\frac{1}{50000}$, (additions,) and map of St. Andrew's bay have been drawn, and preliminary charts of Cedar keys and approaches, $\frac{1}{80000}$, and St. Andrew's bay, $\frac{1}{40000}$, have been engraved.

Triangulation of Cedar keys.—This work was executed by Sub-Assistant B. Huger, jr., for whose party transportation was afforded in the schooner Benjamin Peirce, belonging to the party of Assistant Harrison. The vessel left Jacksonville, Florida, on the 18th of February, but owing to continued bad weather was unable to reach Cedar keys until the 14th of March.

Beginning at Grassy Point, in Waccasassa bay, thet riangulation was carried directly westward as far as Depot key, and includes, besides the stations on the main land, several on Waccasassa reef, and others on reefs intervening between it and the main. Points were also determined and furnished to the topographical party of Assistant Harrison and hydrographic party of Lieut. Comg. Duer. Seventy-three angles were measured in the triangulation upon twenty-one objects by fourteen hundred and ninety-nine observations. The area covered by the triangles is about a hundred square miles.

In a careful reconnaissance made by Sub-Assistant Huger, between Live Oak key and Crystal river, no practicable base was found, and he expresses the opinion that no proper site for one will be found nearer than Acolite key. He remarks, in regard to the character of the surface presented for the continued triangulation: "Many of the station points must be upon oyster reefs, covered at high water. These consist of a rather loose stratum (of broken shells) about two feet in depth, beneath which is the solid oyster bed. The loose stratum shifts during every fresh breeze, and the oyster bed below is nearly as hard as limestone."

The interest and energy manifested by Mr. George E. Humphries, who served as aid in the party of Sub-Assistant Huger, are duly commended in the season's report.

Closing operations in this section on the 28th of May, Mr. Huger, after the completion of his office-work, prosecuted in conjunction with Lieut. A. W. Evans, U. S. A., assistant, the secondary triangulation of the Kennebec river, as described under Section I.

Triangulation of St. Mark's river.—A preliminary base was laid out in December by Sub-Assistant Spencer C. McCorkle, near the city of St. Mark's and Port Leon railroad. The base is twelve hundred metres in length, and was measured with iron wires, occupying nineteen working hours in its measurement.

Signals having been erected to connect properly with the base, observations were begun on the 17th of December, and continued till the 8th of January, during which time seven new stations were occupied in the triangulation between Fort St. Mark's and the light-house at the entrance of the river. Three stations also, erected in previous seasons, were re-occupied.

Four hundred and ninety-two observations were recorded in the measurement of twenty-five angles. The area of the triangulation is about ten square miles.

Transportation for the party of Mr. McCorkle was furnished in the schooner Franklin by Assistant Wise, who also co-operated in the discharge of the duties assigned to the triangulation party. The weather generally was unfavorable for work during the continuance of the parties in this section.

As the triangulation advanced, points were furnished for the execution of the plane-table survey and hydrography.

The notes, journals, and records of Sub-Assistant McCorkle have been received at the Coast Survey office. Remarks made by him in reference to the capacity of the channel at St. Mark's are given as extracted from his report. (Appendix, No. 55.)

Triangulation of Apalachicola harbor.—(*Sketch No.* 30.)—Leaving St. Mark's on closing operations there, the party of Sub-Assistant McCorkle reached Apalachicola on the 15th of January, and was joined by the topographical party in the schooner Franklin on the 1st of the following month.

The parties were visited by Assistant Gerdes, and, with the advantage of his advice and experience, the site for a preliminary base in two lines was selected on the eastern end of St. George's island.

The measurement was begun on the 20th of February, Mr. Wise assisting in the operations throughout. Thirty-six working hours were employed in determining the lengths of the two lines. One of these was found to be 1,780 metres, and the other 1,300, giving for the preliminary base a length of 2,984.6 metres.

Stations, fifteen in number, were erected and secured between the western end of Dog island and the eastern end of St. Vincent's, the limits projected for the triangulation of St. George's sound. Of these, ten were occupied between the 24th of March and 28th of May, the work closing at the last-mentioned date in consequence of the unfavorable nature of the season, but with a view to its completion early in the coming winter.

The area included in this work is about 120 square miles, in which forty-four angles were measured by 1,032 observations. General remarks, contained in the report of Sub-Assistant McCorkle, in regard to facilities for trade afforded at Apalachicola harbor, are given in Appendix No. 55.

Computations of the work of triangulation, and the notes and records connected with it, have been received at the office.

Triangulation of Pensacola harbor and astronomical observations.—Under very favorable circumstances, a preliminary base line was measured by Assistant F. H. Gerdes at Warrington, between the 10th and 12th of April, the apparatus used being that designed by Assistant Hilgard. The western terminus of the base was marked by a screw pile, and the eastern end, having been selected as the astronomical station, was permanently secured by a granite monument. Astronomical observations for latitude and azimuth were made by Sub-Assistant J. G. Oltmanns, attached to the party of Mr. Gerdes. These consisted of sixty observations, with zenith telescope No. 1, on thirteen pairs of stars for latitude, and for azimuth five sets of observations, each six direct and six reversed on Polaris.

The triangulation was extended by Assistant Gerdes from Pensacola city eastward to the entrance of East and Black Water bays, and southward over the bay of Pensacola as far as the island of Santa Rosa. The space yet remaining for completion is that between Pensacola and Yellow Water bay.

Assistant Gerdes remarks on the results of the season: "The triangles close remarkably well, and I have reason to think will be found satisfactory. The inclinations and the expansions of the bars observed in the base measurement were at once reduced and applied in calculation to the triangles determined."

Twenty stations in all were occupied, from which forty separate signals were observed on.

Eighteen hundred single measurements were made with the 12-inch theodolite C. S. No. 16, in the determination of angles. In the progress of the work, which terminated for the present season on the 16th of May, Assistant Gerdes was aided by Mr. R. E. Halter. The schooner "Gerdes," used for transportation, was then laid up at New Orleans, and the instruments shipped for return to the Coast Survey office.

The party was subsequently engaged in the topographical resurvey of New York harbor and vicinity, as stated under Section II.

Assistant Gerdes has sent to the office the journals and notes of the work completed by him at St. Andrew's bay.

Topography of Cedar keys.—Assistant A. M. Harrison having completed the unfinished work of the previous season on St. John's river, as referred to under Section VI, proceeded under instructions to follow the triangulation of Sub-Assistant Huger, with a plane-table survey of Cedar keys. His work in this section commenced on the 29th of March, and is comprised in two sheets, the first showing the main shore, the second the Waccasassa reefs. He also made a plane-table reconnaissance of the Wethloccochee river.

The interval necessary for the determination of points by the triangulation party was employed by Assistant Harrison in a reconnaissance of the Waccasassa river, on the banks of which he erected a number of signals of the third order to facilitate the plane-table survey of the ensuing season. Descriptions and drawings of these have been deposited in the office.

The aggregate statistics of topography executed in the several localities are as follows:

Miles of shore-line	70
Miles of roads	$10\frac{1}{2}$
Area in square miles	16

The health of Assistant Harrison not admitting of his continuance with the party until the close of the season, its operations were conducted by Mr. P. R. Hawley, aid, whose efforts are warmly commended.

The schooner "Peirce" sailed for New York on the 31st of May, and on her arrival there the party engaged in the completion of topographical work for the Commissioners on Harbor Encroachments, as mentioned under Section II.

Interesting remarks and observations made by Assistant Harrison in regard to the nature of the country comprised in the operations on the western coast of Florida will be found in Appendix No. 53.

For facilities afforded by Judge Augustus Steele, of Atseena Otie, while prosecuting the survey in that vicinity, the acknowledgments of Assistant Harrison are expressed in his report. The party is now preparing to return to Section VI.

Four topographical sheets on the scale $\frac{1}{10000}$, comprising the Wethloccochee river, reconnaissance of Waccasassa river, Waccasassa reef, and the country eastward of Cedar keys, have been inked by Assistant Harrison, and are now registered in the office.

Topography of St. Mark's river.—The party of Assistant George D. Wise, after having engaged during the month of December jointly with the party employed in triangulation, as already mentioned, followed in the plane-table survey of St. Mark's river, from points furnished for that object by Sub-Assistant McCorkle.

The topographical sheet comprising the shores of the river between the town and Fort St. Mark's, and the entrance to the harbor, was completed by the 27th of January. A tracing from the sheet, to exhibit the shore-line, was furnished for the use of the hydrographic party. The following statistics have been returned by Mr. Wise:

Miles of shore-line surveyed	50
Miles of roads	6
Area in square miles	25

"The topographical work at St. Mark's was found difficult of execution, owing to the character of the marshes, which are not accessible at low water, and in many places afford no secure footing."

Assistant Wise has inked and deposited in the archives his topographical sheet of St. Mark's river, scale $\frac{1}{20000}$.

Topography of Apalachicola bay.—After completing the survey of St. Mark's, Assistant Wise commenced that of Apalachicola, (on the 30th of January,) assisting, during the progress of joint operations with the triangulation party, in the measurement of the preliminary base. The topographical work was prosecuted until the 20th of May, the sheet containing then the shore-line of the middle parts of St. George's sound, included between Dog island on the east, and the town of Apalachicola on the west, together with the shore-line of the lower part of Apalachicola bay. The limits remaining for completion will extend the survey as far as the eastern end of Dog island on the east, and westward from Apalachicola to Indian Pass, in the vicinity of Cape St. Blas.

The statistics of the present season, which include the survey of the town of Apalachicola, are as follows:

Miles of shore-line surveyed	75
Miles of Gulf coast	25
Area included in sheet, (square miles)	39

The schooner Franklin, after being dismantled, was laid up at Apalachicola on the 30th of May, and Assistant Wise, returning to the north, was employed in his office-work until the period at which the topography referred to under Section III, as since executed by him, was begun. He is now preparing for the return to Apalachicola.

Topography of Pensacola bay.—The topography of the shores of Pensacola bay has been executed by Assistant F. H. Gerdes, based upon the triangulation already referred to. It is comprised in two sheets, one of which (nearly completed) contains the entrance to Pensacola bay, Santa Rosa island, the fortifications, barracks, Navy Yard, and the towns of Warrington and Woolsey; the second, containing the coast topography from the Navy Yard to Escambia bay, and including the city of Pensacola and the opposite shore of Pensacola bay, will be completed during the present winter. These now present the following statistics:

Miles of shore-line	44
Miles of roads	50
Area (square miles)	50

Mr. C. H. Boyd served as aid to Assistant Gerdes in this section, and in the further prosecution, since his return, of the resurvey mentioned under Section II. Two sheets containing the plane-table survey, made during the season at Pensacola, have been inked by Assistant Gerdes and sent to the office.

Hydrography of Cedar keys.—Lieut. Comg. Berryman, on completing the hydrography of St. Andrew's bay, and communicating the necessary information in regard to localities near Cedar keys to his successor in command, was relieved by Lieut. Comg. John K. Duer, U. S. N., assistant in the Coast Survey, on the 16th of April. The soundings made in the present season complete the hydrography of Cedar keys and the approaches, and furnish additional data for the preliminary chart of that locality which accompanied my last annual report, being therein recorded as Sketch No. 33. Tidal observations were made during a half lunation. The statistics of work given in the report of Lieut. Comg. Duer are:

Number of shore stations occupied with theodolite	2
Number of angles determined	693
Total number of soundings	**25,419**

Hydrography of Waccasassa bay and Crystal river offing.—This work, connecting with the eastern limits of the hydrographic survey of Cedar keys, was executed by the party of Lieut. Comg. Duer, between the close of May and the middle of the succeeding month, at which time soundings along the coast had been extended eastward and southward, as far as the northeastern edge of St. Martin's reef, including Waccasassa bay and its approaches, and the entrance to Crystal river.

Special directions deemed necessary, in the opinion of Lieut. Comg. Duer, to be observed by commanders of vessels bound to the harbor of this river are given in the Appendix No. 54.

The statistics of the operations are:

Number of signals established	2
Stations occupied with the theodolite	2
Number of tidal stations	2
Number of angles determined	498
Miles of sounding lines run	346
Total number of soundings	33,174

At the close of the season, the schooner Varina returned to New York with the party of Lieut. Comg. Duer, who has since been employed in office-work.

Preparations are now in progress for the return of the party to this section. The chart of Waccasassa bay, scale $\frac{1}{20000}$, executed by Lieut. Comg. Duer, has been returned to the office and deposited in the archives.

Hydrography of St. Mark's river.—Following the triangulation and topography already noticed, the party of Lieut. Comg. O. H. Berryman, U. S. N., assistant in the Coast Survey, in the schooner *Varina*, commenced the hydrography of St. Mark's on the 10th of March. The soundings include the approaches, entrance, harbor, and the river as far up as the old fort and town of St. Mark's, and were extended a short distance up the branch called Wakulla river. The character of the channel of St. Mark's river is thus described in the report of Lieut. Comg. Berryman: "The river runs over a bed of limestone, between extensive marshes, from St. Mark's to its mouth. The channel is very crooked and narrow. I had occasion to make an examination of the character of the limestone formation at the 'Devil's Elbow,' and found that an iron rod, an inch in diameter and twelve feet long, was easily driven through the top, which seemed to be no more than a crust a few inches in thickness."

The hydrographic survey was completed on the 4th of April, and comprises the following statistics:

Number of stations established	11
Number of tidal stations	3
Angles determined	997
Miles of sounding lines run	367
Total number of soundings	34,456

Hydrography of St. Andrew's bay.—The supplementary work at the approaches, bar and entrance, and in the main harbor of St. Andrew's, was completed by Lieut. Comg. Berryman between January 31 and February 14. The additional results, as presented in the statistics of soundings, &c., are applicable to the preliminary chart of St. Andrew's bay, which appeared in my annual report of last year. (Sketch No. 35, 1855.)

Stations established	4
Angles determined	205
Miles of sounding lines run	137
Total number of soundings	8,210

Tidal observations were recorded during the progress of the work.

Having been relieved by Lieut. Comg. Duer, on completing the hydrography at St. Andrew's bay and St. Mark's river, Lieut. Comg. Berryman returned to New York and was assigned to the command of the steamer "*Vixen*," intended for the hydrography in Section I, and for special researches in the Gulf Stream. The exigency of the government service suggesting, however, that the experience gained by this energetic officer in the cruise of the "Dolphin," in 1853, might be made available in the selection of a proper line for the Trans-Atlantic Telegraph, he was detached in June, and shortly after assumed, under special orders from the Navy Department, the command of the steamer Arctic, for the execution of that important duty. He has since been re-assigned, and is at present engaged in Coast Survey duty in the steamer Vixen.

Two hydrographic sheets of Cedar keys, and two of St. Andrew's bay, scale $\frac{1}{20000}$, one of Ocilla river, scale $\frac{1}{10000}$, and a chart of soundings made by Lieut. Comg. Berryman in the Gulf of Mexico, were turned into the archives of the office in the early part of the season, together with his sheet of hydrographic reconnaissance, scale $\frac{1}{60000}$, of Tampa bay, in Section VI. He has also placed in the office his journals, containing the soundings and angles taken in prosecuting the hydrography of Tampa bay, Ocilla river, and St. Andrew's bay.

Light-houses, &c.—In reply to a call from the Light-house Board regarding aids to navigation which might be deemed necessary in St. Andrew's bay, Florida, a copy of the report of Lieut. Comg. Berryman was transmitted, containing his remarks on the subject, with general suggestions relative to the placing of buoys to facilitate the passage of vessels over the bar. The report will be found in the Appendix No. 85.

SECTION VIII.

FROM MOBILE BAY TO VERMILION BAY, INCLUDING THE COAST OF MISSISSIPPI AND PART OF LOUISIANA.

(SKETCH H, Nos. 33—40.)

This section is about one-third done, but the progress in it during the past year has been more than in that proportion to the whole shore-line, notwithstanding the unforeseen obstacle in the detention of the hydrographic party at the north. The operations are as follows:

1. Preliminaries for determining difference of longitude.
2. The extension of the secondary triangulation on Chandeleur bay, &c.
3. The triangulation of Atchafalaya bay and its topography.
4. The topography of Lake Borgne and East Pearl river.
5. The hydrography of Mississippi sound.
6. Deep-sea soundings and temperatures.

I should be glad to keep two triangulation parties and two topographical parties, besides the hydrographic party having a steam-vessel now employed here, and occasionally an astronomical party, constantly at work in this section. The utmost, however, that the appropriation furnishes is a combined triangulation and topographical party, a triangulation party, a topographical party, and a hydrographic party having a steam-vessel.

Sections VI and VII being much behind this section in progress, I have not felt at liberty especially to push this one forward to completion.

The great work of connecting Mobile and New Orleans, in all its detail, is nearly done. The next season will probably give the telegraphic difference of longitude and the latitudes. They are already connected by triangulation. The plane-table surveys and the hydrography have reached the Pearl river, and hydrography has extended off into the Gulf. A preliminary and a finished map of Mobile bay have been published; the first sheet of Mississippi sound is nearly completed, and the drawings of the other two sheets are in progress; charts of Cat and Ship Island harbors have been published. Reconnaissance maps of the delta of the Mississippi, of Timballier bay, of Barataria bay, and of Pass Fourchon, have been published.

A survey of Isle Dernière has been made and published; but the disastrous hurricane of August

10, 1856, has swept over that island, changing, no doubt, essentially the features of land and water. A general reconnaissance of the coast of this section has been made, so as to determine critically the operations necessary in completing the survey. The portion of the coast from the delta of the Mississippi to Lake Sabine is much more easily surveyed, and requires less detail than the portion bordering on Mississippi sound and the lakes Borgne and Pontchartrain.

Drawings of the Gulf of Mexico, $\frac{1}{2400000}$, (sketch for profiles of deep-sea soundings;) Gulf of Mexico, $\frac{1}{10000000}$, (sketch for co-tidal lines;) seacoast of Alabama and Mississippi, $\frac{1}{200000}$, (preliminary chart;) Biloxi bay, $\frac{1}{40000}$, (finished,) and Mississippi delta, $\frac{1}{200000}$, (reconnaissance,) have been completed, and a finished map of Mississippi sound, No. 2, is in progress. The following have been engraved, or are in progress of engraving: Mobile bay, Mississippi sound, No. 1, $\frac{1}{80000}$, (finished;) and ditto, $\frac{1}{200000}$, (preliminary;) Biloxi bay; deep-sea soundings Gulf of Mexico, and co-tidal lines, $\frac{1}{10000000}$.

For difference of longitude.—A site was selected in the public square of Mobile by Mr. Thomas McDonnell, artificer in the survey, and a station prepared for occupation next year, so as to permit at once the connection of Montgomery and Mobile. Dr. B. A. Gould, Jr., selected a site for the New Orleans station, after considerable examination, upon the open space in the middle of Basin street, about midway between Common and Canal streets.

Triangulation.—The continuation of the primary triangulation in this section, under charge of Assistant J. E. Hilgard, was in progress at the date of my last report. Mr. Hilgard being also charged with work connected with the publication of the Coast Survey records and results, which required his presence in Washington during part of the season, the work was executed in his absence by Sub-Assistant Stephen Harris and Mr. J. S. Harris. Assistant Hilgard rejoined his party early in November, and continued operations until the close of December. In addition to the work previously reported, five primary stations were occupied, at which three hundred and thirty-three measures of angles, each by six repetitions, were taken with the ten-inch (No. 74) and twelve-inch (No. 16) Gambey theodolites.

The primary triangulation is now complete to the line *Cat Island Light—Pitcher Point*, and connects with the *Chandeleur Light*, (see Sketch No. 33.) Great attention was paid to the preservation of station marks, which presents many difficulties here, as in other parts of the coast. Appendix No. 56 gives an extract from Mr. Hilgard's report, showing the means employed by him to secure the stations.

Observations of azimuth were made at Cat Island station, with a twenty-six-inch Würdemann transit, according to a method devised by Mr. Hilgard, and described in his report, (Appendix No. 27.) Six sets were observed with a probable error of $\pm$ 0''.6 for a single set.

The same party continued the supplementary work across the lakes and marshes to the westward, towards New Orleans, and in that direction, seven stations were occupied and thirty-five angles measured. The stations previously determined in the lower part of Lake Borgne, the marks of which had become in a great measure obliterated by storms and decay, were visited, and such additional marks placed upon them as would enable the topographical party to identify them readily.

To close all the triangles in the series to New Orleans, the occupation of station Little Woods (Sketch No. 33) is still required, and the direction from Fort Wood to Bonfouca, which has not yet been obtained. The survey of Lake Pontchartrain will require the erection of a signal in the middle of the lake, and the reoccupation of some of the stations on its eastern shore, including Little Woods, which may, therefore, be postponed until that work is taken up. In the meantime some prominent points about New Orleans are connected by triangles in which two angles are measured.

In his report Assistant Hilgard remarks: "The preparations for observing angles were, throughout the year, kept well in advance of the opportunities for observing; and the periods during which observations were actually made may fairly be stated as including all those when the state of the atmosphere rendered them practicable. I find that observations were principally made in May, June, October, and November, and there was a larger proportion of observing days in June and November than in any other month."

Sub-Assistant J. G. Oltmanns, aided by Mr. R. E. Halter, continued the work he was engaged in at the date of my last report, under the direction of Assistant Hilgard, replacing the signals that had been destroyed by the storm of September, and occupying eight additional stations, in extending the triangulation to the south end of the Chandeleur islands and Freemason's keys.

One hundred and thirty measures of angles were taken, by six repetitions each, with the twelve-inch Gambey theodolite, (No. 16.) See Sketch No. 33. This party closed its operations on the 1st of November, when Mr. Oltmanns was transferred to the work in Atchafalaya bay.

Two volumes, containing descriptions of signals, original and duplicate, two of magnetic observations, and a duplicate of the azimuths observed, have been placed in the archives by Assistant Hilgard.

Triangulation of Atchafalaya bay.—(*Sketch No.* 33.)—The work of this season was commenced by the party of Assistant F. H. Gerdes in the middle of January, at the line joining Belle Isle with the station known as "Central Signal." From there it was carried westward, along the northern shore, and southward, directly over the water of the bay, to Bird key, at the entrance into Côte Blanche bay, various reefs and shoals in the Atchafalaya serving for the erection of the requisite intermediate stations.

The Central Signal, and one erected by the party in 1855 at the Ballast Ground, had been swept away, and required to be re-established from Point au Fer and Belle Isle during the present season of the work.

The statistics of triangulation are thus reported by Assistant Gerdes:

Signals erected and secured	12
Stations occupied	11
Stations and objects observed upon	29
Triangles completed	18
Total number of observations	1,200

The site for a preliminary base was selected on Point au Chevreuil, but being disappointed in the delay in the arrival of the apparatus intended to be used in the determination of its length, five repeated measurements were made with a chain by Sub-Assistant J. G. Oltmanns, under the direction of Mr. Gerdes. The final measurement will be made on the return of the party to this section. The records of the observations made during the season have been deposited in the office.

Topography of Atchafalaya bay.—Proceeding from the points furnished in the progress of the triangulation, the plane-table survey of the northern shore of Atchafalaya bay was continued westward from Belle Isle by Sub-Assistant Oltmanns, attached to the party of Assistant Gerdes.

The sheet of the season comprises the shores of Belle Isle bay; Point au Chevreuil, the western side of which forms part of the shores of Côte Blanche bay; Rabbit key; and Bird key. The length of shore-line determined in the season is twenty-seven and a half miles, within an area of thirty square miles.

The party engaged in the joint work of triangulation and topography, in which Mr. R. E. Halter served as aid, was subsequently employed in similar duties at Pensacola, as mentioned under Section VII.

Sub-Assistant Oltmanns continued during the month of October of last year his survey of the Chandeleur and adjacent islands, and revised the shore-line that had been changed by the storm in September. The additional shore-line surveyed by him is thirty-two miles, (Sketch No. 33.)

Three plane-table sheets of the work executed at Atchafalaya bay, and two of that executed at the Chandeleur islands, have been inked and registered in the archives.

Topography of Lake Borgne and East Pearl river.—After erecting the necessary signals, the party of Assistant R. M. Bache commenced with the plane-table on the 23d of February, and carried forward the survey of the shores of East Pearl river and of the passes connecting with Little lake, adjacent to Pearl River island.

By the 3d of April the topographical sheet included the shore-line on the eastern, northern, and western sides of the island, together with the opposite shores of Pearl river and Little lake, and joined on the east and west with work executed in previous seasons. Operations were then temporarily suspended, but the outside shore-line of Pearl River island, bordering on Lake Borgne, and completing the work in that immediate locality, was determined by Assistant Bache early in May. The party was occupied during the remaining parts of that and the previous month in tracing the western shore-line of Lake Borgne, between the Rigolets and Chef Menteur, and on closing, in consequence of the advance of the season, the work had been brought nearly to a junction with the limits reached by the plane-table in the former part of the year.

The schooner G. M. Bache, which had been, as heretofore, in the service of this party, was laid up at New Orleans on the return of Assistant Bache to the north. He remarks, in reporting the results of the season: "In the country which I have just surveyed the cane was in many places so high as to render necessary the use of a portable platform, and so dense as to greatly impede the movements of the party, requiring sometimes the forward signal to be carried ahead in an extra boat, and the back signal to be sent for in the same way; so that, instead of making from thirty to thirty-five stations in a day, which can readily be done on the outside shore-line, generally only ten could be made, and those with the greatest labor."

Eighty-three miles of shore-line were surveyed during the season, within an area of about twenty-two square miles.

Assistant Bache has been since engaged in a topographical survey in Section I, but is now preparing to resume work on the shores of Lake Borgne.

Hydrography of Mississippi sound, and deep-sea soundings.—This work has been completed along the northern shore, and generally, from the limits reached in the previous season, westward to the meridian of East Pearl river, by the party of Commander B. F. Sands, U. S. N., assistant in the Coast Survey.

My own expectations in regard to the timely commencement of the hydrography, and those of the able officer charged with its execution, were disappointed at the outset of the present surveying year by the long detention of the steamer Walker in the ice of Delaware river. An attempt made as late in the season as the middle of March to clear for the passage entailed some damage to the wheels of the Walker, and further delay at New Castle for repairs.

The vessel being, however, finally freed from embarrassment, efforts were made, in execution of my instructions for the southern passage, to follow the inner cold band of the Gulf Stream below the latitude of Cape Hatteras. This, by reason of stress of weather, was rendered impracticable until Commander Sands had reached a position off Cape Fear. From thence a line of soundings was carried to Cape Cañaveral, a more extended reference to which, as belonging to the hydrography of the Gulf Stream, has been made under that head.

On leaving Key West, a line of deep-sea soundings was run across the Gulf of Mexico from the northwest passage of that harbor to the delta of the Mississippi. The greatest depth at which bottom was obtained was in latitude 26° 39′ N., longitude 84° 46′ W.—the sounding apparatus there indicating 336 fathoms, with 1,250 fathoms of line out. In the next cast beyond this one, the bottom was not reached with 1,290 fathoms of line—the Massey lead marking 960 fathoms. At about two-thirds of the distance from Key West, the operations were interrupted by stormy weather, but again resumed, and soundings carried thence to the delta. Beginning at Pass à L'outre, continuous soundings were carried, on a line eastward, to the middle meridian of Horn island, and then due north to that island.

The interesting results, as to the deep-sea temperatures developed along this line, are shown in the diagrams of Sketch No. 40. Between latitudes 27° 06′ and 28° north, and longitudes 85° 20′ and 86° 39′ west, in the Gulf, at the depths of 421, 610 and 790 fathoms, temperatures as low as 35° and 36° Fahrenheit were reached in the month of April. The lowest temperature in winter, belonging to this region, is about 52° at a depth of 230 fathoms. Does not this, taken in connection with the observations off Cape Florida, show conclusively the passage of the polar current beneath the Gulf Stream, through the Straits of Florida into the Gulf of Mexico, and the underlying of its waters below those of the Gulf? The curve of temperature with depths has the same form as that in the cold current between the Gulf Stream and the Atlantic coast. Is the sudden fall of temperature at this position, where the sudden change of depth takes place, accidental? This is a highly interesting fact for examination, in consequence of the analogies already made out on the southern coast of the Atlantic. The sudden sloping of the bottom of the Gulf is just what was to have been expected from similar determinations elsewhere.

The steamer Walker reached Pass Christian on the 1st of May, but finding the weather yet unfavorable for the execution of the regular hydrography, Commander Sands took the occasion for renewing, at Pensacola, the requisite stock of coal and provisions, and on the departure for his station ran a line with soundings, southward and westward from Pensacola bar, forty-four miles, and from thence to a connection with the off-shore hydrography between Chandeleur and Horn island.

The continued hydrography of Mississippi sound was resumed by Commander Sands on the 5th of May, and prosecuted under favorable circumstances during that and a part of the subsequent month. The work completed before the close of operations, on the 11th of June, comprises the soundings of the northern part of Mississippi sound, from the meridian of the west end of Cat island, westward, to the mouth of East Pearl river—and southward, including Grand Island pass and the bay of St. Louis, to a line joining Cat island and Grand island.

On leaving the section a line of soundings was successfully carried from the entrance of Chandeleur sound to the northwest passage at Key West, which furnishes, with data already obtained, an accurate profile of this part of the Gulf of Mexico. The greatest depth found on this line was 335 fathoms.

Returning northward with the steamer Walker in the latter part of June, Commander Sands made observations at three temperature stations in the axis of the Gulf Stream, north and south of Cape Hatteras, in continuation of his work, extending from the southward in the previous year.

The following are the statistics of hydrographic work executed within the past season in Section VIII, or in immediate connection with the operations of the party of Commander Sands in that section:

Localities in the Gulf of Mexico.	Miles run in soundings.	Casts of the lead.
Deep-sea line from Key West to Mississippi delta	210	35
Deep-sea line from Pass à l'Outre to Horn island	80	12
Deep-sea line from Pensacola to Chandeleur sound	97	31
Deep-sea line from Chandeleur sound to Key West	521	49
Hydrography of Mississippi sound	808	62,307
	1,716	62,434
Angles determined for hydrographic purposes	1,478	

Since the opening of the surveying season Commander Sands has returned for deposit in the archives, his chart of resurvey of Pelican channel; survey of Biloxi bay; reconnaissance of Vermilion bay and Calcasieu river, and two sheets of Mississippi sound, scale $\frac{1}{10000}$, together with two charts, showing soundings and temperatures in the Gulf of Mexico, the originals and duplicate records of soundings and angles, and twenty specimens of bottom from the Gulf of Mexico.

Tides.—A brief notice of the progress made in discussing the tidal observations of the Gulf coast is given in the introduction to this report, and the results are detailed in the Appendix No. 35, in a paper on cotidal lines, read by me before the American Association for the advancement of Science.

SECTION IX.

FROM VERMILION BAY TO THE BOUNDARY, INCLUDING PART OF THE COAST OF LOUISIANA, AND THAT OF TEXAS.—(SKETCH I, Nos. 41—43.)

This section is well advanced, notwithstanding the peculiarly disadvantageous circumstances under which the work in it has labored from time to time. I estimate that it is one-third done, and that it can easily be brought out before the other Gulf sections, with the force at present employed in it. The great work was Galveston bay and its dependencies, executed now some years since, and published in sketches and preliminary charts, and nearly ready in a finished map. The occasional services of an astronomical party, and the regular services of one triangulation, one topographical, and one hydrographic party with a sailing vessel, will bring the work to a close between Matagorda bay and the boundary, unless extraordinary detention occur, in six years; and in two or three years more the work, from East bay to Vermilion bay, may be completed by a similar force. The only part of this coast which presented difficulties has been passed, and the work goes now rapidly onward, the topography and hydrography keeping pace with the triangulation without essential difficulty. It will be necessary, in order to produce this result, to keep the same parties during, at least, half of this time on this particular part of the coast. The frequent changes in the assistants employed have much retarded the progress in past years, the first season being in a great degree required to give the experience necessary, and to know what means are best suited to the particular circumstances and localities of the work to make the best use of the means provided. The first effort was made in this section by borrowing a revenue-cutter from the Treasury Department in 1847, and the first permanent operations of the Coast Survey were conducted with very small means in 1848. One year since, nearly the whole available appropriation for this section was absorbed in providing a suitable vessel, the schooner Arago, for the hydrographic party.

The following operations are detailed in this section:

1. Triangulation of Matagorda bay.
2. Topography of Matagorda bay.
3. Hydrography of the coast of Texas, south of Galveston bay.

The drawing and engraving of the preliminary chart of Galveston bay $\frac{1}{100000}$, has been completed.

Secondary Triangulation of Matagorda bay.—(*Sketch No.* 41.)—The party of Assistant S. A. Gilbert reached Matagorda on the 18th of January in the schooner Phœnix, and employed the following month in the erection of signals, and in reconnaissance for the work of the season. The instruments shipped to the party having been lost in the wreck of the steamer Crescent City, others were sent from the office to replace them, and the measurements of angles were commenced on the 20th of February.

For the triangulation, twenty-three tripod signals were erected in Palacios and Lavacca bays, and in other dependencies of Matagorda bay, the work being extended in a direction westward from the limits of the triangulation of the previous year. Ten stations were occupied by Assistant Gilbert; at nine of which observations for horizontal angles were made from the tripod heads at elevations varying between twenty and forty-three feet. At these stations fifty-eight angles were measured on forty-three different objects. The area covered by the triangulation is about three hundred and twenty-four square miles.

"The general character of the country is level prairie, much cut up with low, wet, boggy tracts and small bayous.

"There is no timber excepting on the islands in the Colorado bottom, and on the immediate banks where the land is low and subject to frequent inundations, and in those localities a very dense growth of cotton-wood, cypress, gum, and other varieties, interlaced with vines of various kinds, forms an almost impenetrable thicket."

"Through the islands, between the two mouths of the Colorado, run innumerable small bayous and channels, which are generally so choked up by fallen trees and drift-wood as to be inaccessible for boats of any kind."

"The trade in the river is limited, and by reason of the shell reef obstructing the navigation at Dog island, where the water, as well as at the mouth of the river, is lessened to two and a half feet, sea-going vessels, engaged in carrying sugar and cotton from Matagorda to New York, are under the necessity of receiving and discharging their cargoes by lighters at Shell island, at a distance of eight miles southwest of the town of Matagorda."

"The shores of Lavacca bay, in the upper part, rise from fifteen to twenty feet above the water level."

Sub-Assistant Malcolm Seaton was attached to the party engaged in the triangulation, and his zeal, industry, and efficiency in the prosecution of the work are acknowledged in cordial terms in the report of Assistant Gilbert. Operations in the joint duty of triangulation and topography were terminated for the season on the 12th of May.

Topography of Matagorda bay.—In connection with the work just noticed, the plane-table survey of the peninsula separating Matagorda bay from the waters of the Gulf of Mexico was completed by the party of Assistant Gilbert. The work joins at Smith signal with the sheet of Sub-Assistant Sullivan, to be presently mentioned, and was extended from thence southward and westward to Decros Point. The shores of the mainland, on the opposite side of Matagorda bay, are included in the topographical sheets of Assistant Gilbert; the details of that extending eastward from Matagorda, commenced last eason, being also completed.

The topography of the mainland is comprised between Lake Austin on the east, and the entrance to Palacios bay on the west, and the details in reference to the statistics are exclusive of those returned for the sheet commenced in the previous year. The summary for the present season is as follows:

Shore-line surveyed	234 miles.
Roads surveyed	5 "
Square miles of area	108

This work, with that of the party of Sub-Assistant Sullivan, to be next noticed, completes the survey of the upper part of Matagorda bay, and as far as the junction formed by its waters with those of Palacios bay and Lavacca bay. In reference to the character of the region included in his topographical survey, Assistant Gilbert remarks that:

"About a mile back from Matagorda bay the prairie is above the ordinary high water of the rivers or tide, and appears to be rich and fertile; but in general, the lands around the bay, and for miles in the interior, are used only as grazing ground for the immense herds of cattle raised in the vicinity of Matagorda."

On closing the work of triangulation and topography in Matagorda bay, the schooner Phœnix was refitted for her return to New Orleans, where she arrived on the 1st of June, and was soon after laid up for the season at Madisonville. Assistant Gilbert returning to the north completed his office-work, and in the latter part of August resumed topographical duty on Long Island, as detailed under Section II. This duty has been continued until the present time, but active preparations are in progress for an early return of the party to Section IX.

The topography of the peninsula, at the upper extremity of Matagorda bay, was executed by Sub-Assistant J. A. Sullivan.

Transportation was afforded for his party in the schooner Phœnix, which was during the season engaged, as just stated, in the service of the triangulation party of Assistant Gilbert at work lower down on the coast.

Mr. Sullivan commenced his sheet on the 31st of January, and completed the survey of the peninsula between Cany creek and Smith's house and landing, including the coast of the Gulf of Mexico, lying between the points named. The extent of coast line determined and defined on the sheet is about nine and a half miles. The survey of the main land was carried towards the interior along Cany creek, embracing both its shores, and on the lower side as far back as Lake Austin, a part of which and of Live Oak bayou, on the shores of Matagorda bay, were also included. Numerous intricate watercourses, and other features comprised within the limits just mentioned, are amongst the details returned on the map sent to the office by Mr. Sullivan.

"The peninsula, from the head of Matagorda bay to Smith's signal, is very much cut up with bayous, some of which, when the tide is high, connect the waters of the bay with the Gulf of Mexico. The bay shore is fringed with bushes, and is very uneven and marshy to an average distance back of about one hundred and fifty metres."

"Cany creek was surveyed to a station which, though not over four miles above the mouth of the canal in a direct line, is thirteen miles distant, measured by the watercourse. The creek runs through a belt of woods varying from fifty to two hundred and fifty metres in width, with a dense undergrowth, which extends to the water's edge."

The following are statistics of the work executed:

Miles of shore-line surveyed	145
Miles of roads surveyed	18½

Sub-Assistant Sullivan discharged his party in the beginning of April, and proceeded, under my instructions, to act in concert with Sub-Assistant Rockwell for continuing the triangulation of the Florida keys, reference to which has been made under Section VI. He was since engaged in topographical work requisite in the resurvey of New York harbor.

The topographical sheet of Sub-Assistant Sullivan has been deposited in the office, and will be inked during the winter.

Hydrography, coast of Texas.—The party of Lieut. Comg. Edwin J. De Haven, U. S. N., assistant in the Coast Survey, in the schooner Arago, reached the station joining the limits which terminated the work of the previous season, southward of Galveston bay, about the middle of December. After making a proper connection with the hydrographic sheet last executed, the soundings were resumed at "Jupiter" station, about three miles below Velasco, and continued southward and westward along the coast, and for about twelve miles off shore to "Bath" station on the peninsula below the head of Matagorda bay. The hydrographic sheet, including this work, extends thirty-one miles along the coast. An examination was also made of the soundings executed in the previous year. In prosecuting the work of the present surveying season, nineteen thousand one hundred and fifty-two soundings were made.

Lieut. Comg. De Haven has completed, and turned in for deposit in the archives, his hydrographic sheet containing the upper part of Galveston bay, and four sheets, scale $\frac{1}{20000}$, of soundings executed westward of Galveston bar, together with his chart of work extending from Quintana westward, and the following records of observations made during the progress of the survey by his party in the section, viz: Ten volumes of soundings, and the same number of volumes of angles entered in the work of upper Galveston bay, off Galveston bar, and westward of it; two journals of the same, and four volumes original and duplicate of tidal observations made at Bolivar Point, Galveston bay, San Luis, and San Bernard river. He has also returned six volumes of soundings, seven of recorded angles, and a volume of tidal records containing the data obtained this season.

SECTION X.

COAST OF CALIFORNIA, FROM THE SOUTHERN BOUNDARY TO THE FORTY-SECOND PARALLEL, NORTH LATITUDE. (SKETCH J, Nos. 44—50.)

The details of operations in this section will be found to include:

1. The extension of the primary triangulation northward of San Francisco bay.
2. The triangulation of the main, adjacent to Santa Barbara channel, and of Santa Cruz island.
3. The topography of San Francisco and San Pablo bays.
4. The topography of the main, adjacent to Santa Barbara channel.
5. The hydrography of San Pablo bay, of Mare Island straits, of San Clemente anchorage, of San Diego bar, of Cortez shoal, and of part of Santa Barbara channel.

Primary triangulation.—The work extending northward from San Francisco bay has been, during the season, in charge of Assistant George A. Fairfield. From the termination of the series of triangles completed by Assistant R. D. Cutts, between Monterey and Rocky mound, the divergence of the mountain ranges was found to increase, necessarily involving the selection of lines of greater length, and, under ordinary circumstances of the season, enhancing the difficulties to be expected in making the observations. Two primary stations have been occupied by Assistant Fairfield in the extension of the work from Ballenas bay to Russian river. The number of angles measured within the season was thirty-one by twenty-seven hundred and seventy-nine observations. Twelve primary signals were erected, and the heights of the two stations occupied were determined by the level.

Tomales bay and Bodega bay were included in secondary triangulation.

Descriptions of the signals erected by Assistant R. D. Cutts, and of the stations established by him on the shores of San Francisco bay and southward to Monterey, have been received from him within the year, and placed with the records of the triangulation.

Triangulation of the main, adjacent to Santa Barbara channel, and of Santa Cruz island.—The plan proposed for connecting the islands in Santa Barbara channel, by triangulation, with stations established on the main coast near Point Fermin, has been pressed forward by Assistant W. E. Greenwell. After the completion of a reconnaissance, he projected a series of triangles to extend from San Pedro, northward and westward, stretching over the villages of San Fernando and Santa Clara, and resting at a station near the mission of San Buenaventura, from which it is expected that a junction may be formed with the islands of Santa Cruz, Santa Rosa, and San Miguel. Observations were begun at San Pedro, and, as an example of the peculiar difficulty presented in this work, the party in occupying that station for two consecutive months were not able once to distinguish either the signal on Santa Barbara island or that erected on Point Duma, although the latter station is but twenty-seven miles, and the former only about forty miles distant. The exertions of Assistant Greenwell were subsequently successful in completing the triangulation between these points upon the basis of his reconnaissance already referred to. Four primary and fifteen secondary stations were observed on within the season. The number of observations made was fourteen hundred and two, with the eight-inch Gambey theodolite, C. S. No. 44.

In October, Mr. Greenwell measured a base of six hundred and ninety metres near the middle of Santa Cruz, and has made progress in the triangulation of that island preparatory to the plane-table survey and its connection with the work on the main. The topography of Santa Cruz island and that of Santa Rosa will be commenced early in the ensuing year.

Having effected a landing upon Santa Barbara island, without accident, although at considerable risk, Assistant Greenwell erected a signal there just previous to the opening of the present surveying year. He remarks, "Since then, I visited the island again, for the purpose of leaving a heliotroper, but, after two days spent in fruitless efforts to land, was at length forced to abandon the attempt. The extent of this little island in shore-line would not exceed two miles. Its elevation in the highest part is about five hundred feet, and the surface contains some twenty or thirty acres covered with soil, but no water occurs, and not a vestige of wood. The shores are rocky and abrupt, presenting on the northeast and on the southern side perpendicular surfaces, exposed to the full force of the ocean swell."

"Catalina island is about seventeen miles in length, with, at most, a breadth of four or five miles. Its shores are rocky, and on the southern side fearfully abrupt, but on the northern shore, in several little coves or bays, boats may land at any season of the year. For agricultural purposes I consider this island valueless. It is made up of ridges of rock, running diagonally across the surface from northeast to southwest, with elevations of from two to three thousand feet, composed principally of slate rock, with occasional masses of coarse quartz. Between these ridges occur precipitous gulches, and at intervals little valleys, but they are inconsiderable, and the soil is light and scarcely worth the cultivation."

"Four or five settlers cultivate the most productive of the little valleys mentioned, but realize nothing beyond the bare means of living. About midway between the isthmus and the northwestern extremity of the island, there is a well of running water, sweet and good. At the southeastern point, good water has also been found in digging to a depth of fifty feet or more; but in places intermediate, although found at the same depth, the water is brackish. The island of Santa Catalina produces good firewood, (scrub oak,) and much of it could be obtained without extraordinary labor."

Mr. P. C. F. West served as aid in the party of Assistant Greenwell.

The schooner Humboldt, used for transportation, was laid up at San Francisco on closing work for the season.

Topography of San Francisco and San Pablo bays.—The party of Sub-Assistant Augustus F. Rodgers has completed the plane-table survey of the northern shore of San Pablo bay, extending it eastward from the limit reached last season in the vicinity of the mouth of Petaluma creek. Several navigable streams, known as Folay and Sonoma creeks, and Navy Yard slough, are included in the topographical sheet. This work was executed in March. A second sheet, completed in May, embraces the shores of Napa or Mare Island strait, including the works in progress in the vicinity of the Navy Yard, and a plan of those contemplated, together with a survey of the town of Vallejo, on the opposite eastern shore of the strait. The details of these two surveys exhibit the connection between the waters of Napa and Sonoma creeks, hitherto but little known; the surveying schooner Baltimore, in the service of the topographical party, being the first vessel of like draught known to have passed through.

In July, Sub-Assistant Rodgers completed a topographical sheet containing the shores of Karquines strait, and the southern part of Suisun bay, connecting with that last mentioned; and in August a fourth sheet, presenting the shores of San Antonio creek with the adjacent eastern shore of San Francisco bay. The fifth plane-table sheet, which closed his work of the present season, embraces the eastern shore of San Francisco bay. This survey joins with the former sheet at the mouth of San Antonio creek, and extends northward and westward to the station Contra Costa, No. 3, opposite the main entrance of the bay.

The topographical statistics of the season are as follows:

Sheets.	Miles of shore-line.	Miles of roads.	Area, square miles.
No. 21	249.87		19.75
22	137.25		13.75
23	46.40	10.00	20.50
24	83.50	28.50	10.30
25	21.00	29.25	9.00
Total	538.02	67.75	73.30

The city of Benicia and the towns of Vallejo, Martinez, Oakland, San Antonio, and Clinton are included in the plane-table sheets just mentioned.

In his report of operations, Sub-Assistant Rodgers remarks: "The town of Vallejo has within the last year assumed the appearance of a thriving place, having now a population of about eight hundred souls.

"The city of Oakland and its vicinity will furnish an interesting example of the rapid progress of settlement in California. The villages of San Antonio and Clinton, which had no existence four years ago, now form a prominent feature on the eastern shore of San Francisco bay; though still unimportant in themselves, they have recently been joined under the name of *Brooklyntown.*"

The prevalence of fogs in the vicinity of San Francisco during the season, and rapid alterations of natural feature in topographical details, yet going on with the progress of development, made it expedient to defer until the ensuing season the survey of that city. Under ordinary circumstances of weather, and other contingencies affecting operations in the field, the survey of the shores of San Francisco bay and its dependencies, including the city of San Francisco, will probably be completed before the close of the next ensuing year.

Six topographical sheets of the survey of San Francisco bay have been received from Sub-Assistant Rodgers since the close of last season, and filed with the archives of the Coast Survey office.

Tracings from these were furnished, during the progress of work, to the hydrographic party. The two sheets embracing Oakland and vicinity are reported as well advanced for forwarding to the office.

Topography of the main, adjacent to Santa Barbara channel.—The party of Sub-Assistant W. M. Johnson took the field early in April, and during the season executed two plane-table sheets, embracing a part of the coast bordering on the Santa Barbara channel. The first of these commences at Santa Clara river, and exhibits the ocean shore-line and the topographical features in detail of the main, between it and Point Hueneme, where it joins the second sheet. The survey was from thence continued in the same direction, southward and eastward, along the shore of the channel to Point Mugu. Above eighteen miles of outer coast-line are represented in the two sheets, the first of which has been returned and deposited in the office. The season proved to be very unfavorable for the operations of the party. Sub-Assistant Johnson made a reconnaissance from the limit reached in the topographical survey—to Point Duma, distant rather more than twenty miles, and remarks in reference to the general features of the country: "So broken is this part of the coast that we did not reach Point Duma until the approach of night on the second day after leaving camp, though moving at sunrise. There is but little water and very little land that will ever be fit for cultivation; the only rancho passed on our route was within a mile of Point Duma."

Sub-Assistant Johnson was engaged during part of the season in tracing in the shore-line of his work on Monterey bay, north of Point Año Nuevo, and north of Point Duma, and in the preparation of other topographical data, for the use of the hydrographic party of Commander Alden.

The statistics of the plane-table work executed are as follows:

Shore-line of coast surveyed	18½ miles.
Shore-line of sloughs and ponds	40¾ miles.
Shore-line of roads	6 miles.

Since the opening of the season three plane-table sheets, forwarded to the office by Sub-Assistant Johnson, have been registered and deposited in the archives. One of these contains the survey made by him of Anacapa island and part of Santa Cruz, in the early part of the year.

Hydrography.—The hydrography of this section was interrupted during the past year by the use made of the steamer Active, under Commander Alden, in the Indian war in Washington Territory. The conduct of Captain Alden, in volunteering his services, and those of his party, was approved by me and by the Department.—(See Appendix No. 73.) The survey, however, was deprived of efficient services from December, 1855, until the middle of March following, except during a short period when Blakely harbor, Washington Territory, was surveyed.

In May, the steamer Active and schooner Ewing were employed in attempts to survey the Cortez shoal, but the weather proving boisterous, the examination was deferred until later in the season. The vicinity of the island of San Clemente was surveyed, and the vessels proceeded to San Diego harbor, completing soundings there between the 16th of June and 28th of July.

Just after leaving San Francisco, the vessels proceeded to Monterey, and Commander Alden visited Carmel bay, "for the purpose of examining a small harbor in that vicinity, which I had been informed was a safe anchorage at all seasons. I found a small nook at the southern extremity of Carmel bay, sufficiently land-locked, but too small for a vessel of this size to swing comfortably at anchor. There is an extensive quarry of granite at this point, and several vessels are employed in its transportation to San Francisco, but there is so little room that they are compelled to warp out and in by buoys placed at the entrance."

In reference to the work at San Diego, Commander Alden remarks:

"We found *a bar* at the entrance to that port. It is situated between the outer extremity of Point Loma and the tail of Zuninga shoal. The bar is five hundred yards wide between the outer and inner five-fathom curves, and has only twenty feet at mean low water, at the shoalest point."

On the 30th of July the schooner was taken in tow of the Active, and, at the close of the day following, the steamer succeeded in anchoring in eleven fathoms on Cortez shoal.

"The Ewing having anchored in the same depth of water, and just far enough off (about two miles) to give a good base for operations, at daylight next morning the work was begun; and an astronomical bearing having been taken on the schooner, a boat with a large signal was left to occupy our position, while soundings on the line were executed in the steamer Active; after which the schooner or boat was fleeted as occasion required. In like manner, the whole area of the shoal (a hundred and thirty square miles) was sounded out."

A spot having probably as little as three fathoms of water at low tide was struck in the latitude of the least water found by Lieut. Comg. McRae, and somewhat less than half a mile to the eastward of the position assigned by that officer for the point of rock detected by him in the examination of the previous year.

A consideration of the highly favorable circumstances under which the complete survey of the shoal was made by Commander Alden leads to the conclusion that the single point of rock found in both examinations is identical. He adds further: "We had a fair opportunity to give the bank a thorough examination, and I am satisfied that the spot on which we got three and a half fathoms—say three fathoms at low water—is the only point at all dangerous to navigation, except perhaps in heavy weather, when it breaks in five or six fathoms on the shoal, and sometimes, I suppose, in much deeper water."

On the departure of Commander Alden for Puget's Sound, the schooner Ewing was left in charge of Lieut. Comg. R. M. Cuyler, U. S. N., assistant in the Coast Survey, for the execution of the hydrography of San Pablo bay. This work was completed before the end of March. Mare Island strait, with a part of Karquines strait, was sounded out while the vessels of the party were undergoing repairs in April. Commander Alden remarks, in connection with the work in this vicinity: "In our examination about Commission Rock, it was discovered to extend much further into the main ship-channel than was at first supposed. We found fourteen feet of water fifty metres from the point of rock, which is bare at low water, reducing the width of the channel between the eighteen feet curves to about two hundred and twenty yards."

Observations were made on the currents of Santa Barbara channel by Lieut. Comg. Cuyler, in the schooner Ewing, and from this work, which was continued as the nature of the season permitted, the following conclusions have been reached by that officer: "From the observations already made, I deduce that in Santa Barbara channel, close in with the main land, and out from it about four miles, the current runs constantly during summer to the westward and northward and westward, with a maximum velocity of a knot and a half per hour. Further out in the channel it is not so strong, and often runs to the northward and eastward and southward and eastward; but even there its greatest velocity is attained when running to the westward. At Point Conception the set is constantly to the southward and westward."

"On Cortez shoal the general set of the current is southward and eastward, and the greatest velocity a knot and a half per hour."

These conclusions confirm, so far as they go, the results of observations begun under my instructions by the late Lieut. Comg. Archibald McRae, U. S. N. The untimely death of that intelligent and energetic officer, and causes arising subsequently in consequence of the absence of Commander Alden in Section XI, have devolved the completion of this duty upon Lieut. Comg. Cuyler.

Following the shore-line of Santa Barbara channel on the main, between San Buenaventura and Point Duma, furnished by Sub-Assistant W. M. Johnson, the soundings by the hydrographic party kept even pace with the field-work until the close of the season.

The statistic summary of hydrographic work is thus stated in the season's report:

Localities.	Miles of soundings.	Angles observed.	Casts of the lead.	Current stations occupied.
San Pablo bay	681	423	10,830	4
Mare Island straits	125	565	4,070	
San Clemente anchorage	30	75	500	
San Diego harbor and vicinity	537	2,727	12,739	
Cortez shoal	206	87	783	4
Santa Barbara channel	114	478	1,780	16
Total	1,693	4,355	30,702	24

Twelve specimens of the bottom were obtained with the soundings in the Santa Barbara channel. The hydrographic party is at present engaged in the execution of the hydrography between San Buenaventura and Point Duma on the main bordering the channel.

Commander Alden has sent to the office within the year charts of the following localities in this section:

Vicinity of Anacapa and eastern end of Santa Cruz island	$\frac{1}{10000}$
San Buenaventura and vicinity	$\frac{1}{10000}$
Sauquel cove, Monterey bay	$\frac{1}{10000}$
William's Landing and vicinity (two sheets)	$\frac{1}{1000}$
San Francisco bay (four sheets)	$\frac{1}{10000}$
San Francisco bay, No. 4	$\frac{1}{20000}$
San Pablo bay	$\frac{1}{20000}$
Crescent City harbor (resurvey)	$\frac{1}{10000}$

Tidal observations.—The permanent tidal stations at San Diego, San Francisco, and Astoria, have been kept up during the surveying season. As stated in my previous annual reports, the operations were continued in the charge of Lieutenant W. P. Trowbridge, but, in view of his return to the Atlantic coast in April, arrangements which met the concurrence of the Chief Engineer, General Totten, were concluded with Colonel DeRussy, for maintaining the permanent stations on the Western Coast. This service was voluntarily undertaken by Lieutenant N. F. Alexander, of the Corps of Engineers, and the skill and success shown by that officer in its accomplishment have been such as to command my thanks and approbation.

A short series of observations was made with the self-registering gauge at Cuyler's harbor, island of San Miguel, to fill the interval mentioned in my last annual report as occurring between the stations at San Diego and San Pedro.

Light-house examination.—Since the date of my communication (October 11, 1855) reporting progress made in the re-examination of the islands of Santa Cruz and Anacapa, and of the main adjacent to Santa Barbara channel, that duty has been completed in the selection of a point southeast of San Buenaventura for the establishment of a seacoast light. The service was executed by Lieut. Comg. Archibald MacRae, U. S. N., assistant in the Coast Survey. The reasons determining the choice of the site referred to, are stated in detail in his report upon concluding the re-examination. (Appendix No. 86.)

SECTION XI.

COAST OF OREGON AND WASHINGTON TERRITORIES.—(SKETCH K, Nos. 51—60.)

Notwithstanding the interruption to the hydrography of this section by the occupation of the steamer Active in operations connected with the Indian war, the survey has made definite progress. Astronomical observations were made at Point Hudson, Washington Territory. A base was measured at Port Townshend, and the triangulation of Admiralty Inlet was continued into Hood's canal. The topography of Port Townshend and of Port Gamble, and the entrance to Hood's canal, was executed, and sketches of Apple and Murden's coves were made. The hydrography of Blakely harbor was executed. A list of the maps turned in by the hydrographic party is given in this chapter with the details of the other work.

Astronomical observations.—Having wintered at San Francisco, and completed his office-work of last year in this section, Assistant George Davidson returned with his party in the brig Fauntleroy, to Admiralty Inlet, and commenced the operations of the season by observing the occultations of α Scorpii and the planet Mars, in connection with the usual means for determinations of chronometer rate and other instrumental corrections. The observatory was erected at Point Hudson, for the meridian of which the occultations had been calculated. A meridian mark was established and observations commenced for the determination of azimuth for the adjustment of the triangulation. On five consecutive nights, one hundred and ninety-two observations were made for the angle between α Ursæ Minoris at eastern elongation and the station Point Wilson, and one hundred and fourteen observations for that between δ Ursæ Minoris at eastern elongation and Point Wilson. The same number of observations were made for the azimuth between that station and Admiralty Head. The elongation mark was in the line beyond Point Wilson, and distant two miles from the azimuth station. The ten-inch theodolite, C. S. No. 20, was used in the observations.

Triangulation of Admiralty Inlet.—After measuring the base selected at Port Townshend, and occupying some of the stations established last season, Assistant Davidson proceeded with the triangulation from the limits then reached, and extended it westward, opening on Fuca strait, and southward over the inlet and its dependencies in the direction of Puget's Sound, into Hood's canal, Possession Sound, and the adjacent waters, and including Port Discovery. Stations were selected for connecting with the work to be executed in the straits of Fuca, Rosario strait, and Canal de Haro. A reconnaissance was made beyond Duwamish bay, and seventy-five signals erected for continuing the observations. In the measurement of vertical angles, Mr. Davidson made one hundred and thirteen observations at these stations, and determined the heights of sixteen objects. He reports for Mount Baker, an active volcano, an elevation of 10,495 feet, and for Mount Constance, the eastern sharp peak of the Olympus range, a height of 7,777 feet. The instrument used in these determinations was the vertical circle, C. S. No. 80. The season proved generally unfavorable for field-work in this section, the observations in triangulation being much hindered by lateral refraction.

The following are the statistics of the season:

Number of signals re-examined	37
Number of signals erected and determined	95
Stations occupied during the season	60
Angles measured	299
Separate observations in measurement	9,816

Sub-Assistant James S. Lawson, attached to the party of Assistant Davidson, participated in the execution of the triangulation at the entrance to Hood's canal, and other work in the field.

Under the direction of Mr. Davidson, a signal was erected near the site for the light-house at New Dungeness, and Sub-Assistant Lawson succeeded in connecting the station with his triangulation of that locality.

Nine volumes, containing notes and records of Mr. Davidson's work at San Pedro and in Rosario strait and Admiralty Inlet, and also descriptions of the signals erected, have been received at the office.

Topography.—Sub-Assistant James S. Lawson, attached to the party of Assistant Davidson, has completed the plane-table survey of Port Townshend and approaches, and of Port Gamble, westward to Point Salisbury and Termination, embracing both sides of Hood's canal, and extending northward halfway to its entrance. Sketches of Apple cove and Murden's cove have also been executed by Mr. Davidson and Mr. Lawson. The points necessary for the execution of this work were furnished by the triangulation party. The shore-line, comprising over forty-one miles within the limits of triangulation, was approximately traced by Assistant Davidson.

Mr. Lawson levelled the base at Port Townshend, and has furnished a profile and sketch of the site for reference.

The statistics of his work are as follows:

Shore-line surveyed	71½ miles.
Area of topographical sheets, (square miles)	18

He is at present engaged in inking the sheets executed within the season.

Sub-Assistant Lawson's plane-table sheets, on the scale of $\frac{1}{10000}$, of Port Ludlow, Smith's Island, New Dungeness, and Mats-Mats, or Boat harbor, have been received and deposited with the archives.

Measurement of Port Townshend base.—In July Assistant George Davidson measured at Port Townshend a base 2,869.5 metres in length upon the site selected in the previous season, using the two iron rods, each of four metres, employed by Assistant R. D. Cutts in determining the length of the Pulgas base, in Section X. More than two-thirds of the base at Port Townshend runs over a space covered by the tide, but the level sandy bottom admitted of good progress, though less than half of each of the four days employed in the measurement were available on account of the water.

Mr. Davidson followed in the measurement the method used by him in April, 1853, at Los Angeles. The ends of the base at Port Townshend have been well marked below the ground, and will, as soon as practicable, be distinguished by marks of the usual kind above the surface.

Hydrography of Blakely harbor.—While engaged with the surveying steamer Active, in the special duty for the Navy Department, of assisting to repel Indian hostilities in Washington Territory, as referred to in Appendix No. 73, it was expected that occasional opportunities might offer for advancing the hydrography of this section. But the Active being the only steam-vessel available for the service in Puget's Sound, she was constantly in requisition during the three months following the 15th of December, and actually ran, as shown by the log, an aggregate distance of over four thousand miles between seventy-nine different anchorages. Before leaving the section, however, Commander Alden executed a hydrographic survey of Blakely harbor, the statistics of which are as follows:

Miles run in soundings	16
Angles observed	150
Total number of soundings	398
Area surveyed, (square miles)	2

Since the date of my last annual report, the following hydrographic sheets of localities in Section XI have been forwarded to the office by Commander Alden:

Shoal water bay, No. 2.	
New Dungeness	$\frac{1}{10000}$
Olympia harbor	$\frac{1}{10000}$
Port Ludlow	$\frac{1}{10000}$
Port Gamble	$\frac{1}{10000}$
Admiralty Inlet	$\frac{1}{100000}$
Steilacoom harbor and vicinity	$\frac{1}{10000}$
Bellingham bay	$\frac{1}{20000}$
Blakely harbor	$\frac{1}{10000}$

Magnetic observations.—While observing at Point Hudson for azimuth, Mr. Davidson determined the magnetic declination, making one hundred and thirty observations upon four days for that purpose. He redetermined also the zero points of the magnets and the co-efficient of torsion. The instrument used was the magnetometer, U. S. C. S., No. 3.

OFFICE-WORK.

From the 1st of November, 1855, until the 21st of May, 1856, (nearly seven months,) the Coast Survey office was under the charge of Captain W. R. Palmer, U. S. Topographical Engineers, and during the remainder of the year under that of Captain H. W. Benham, of the Corps of Engineers. The work in general has made satisfactory progress in all the divisions under both of these accomplished officers.

Captain Benham was assigned to the important duty of examining the engraving establishments of Europe, with a view to increase the number of our first-class engravers, in November of 1855, and returned in June, 1856. In November, I made a close examination of all the parts of the office, and again in May. The details of progress are generally from the report of Captain Benham made at the close of October, and of the chiefs of the office divisions accompanying it.

The divisions of the office are the following:

1. Computing; 2. Tidal; 3. Drawing; 4. Engraving; 5. Electrotyping; 6. Miscellaneous.

1. Computing Division.—This division has been during the year under the charge of *Assistant Charles A. Schott*, and has fully maintained the high character of former years for zeal and efficiency, and for progress. The papers contributed by Mr. Schott, and forming part of the Appendix to this report, are evidences of his successful labors out of the routine of the division. The regular work has been kept up, and the numerous calls from the field parties and from persons outside of the survey, have been duly answered.

The computations have been distributed as follows: *Mr. E. Nulty* has made latitude and azimuth computations, and reductions of magnetic declinations, dips, and intensities; *Assistant T. W. Werner* has been engaged on the various calculations of triangulations, and on the extension of projection tables; *Mr. James Main* has reduced magnetic declinations, dips, and intensities, completed and revised astronomical azimuths and longitudes, and put the results in shape for publication. *Mr. G. Rumpf* has computed, revised, and adjusted various triangulations, and had charge of the registers of geographical positions and geodetic statistics. *Mr. J. Weisner* has reduced transit observations, and computed chronometric differences of longitudes, and generally assisted on reductions of triangulations and other calculations. *Mr. J. H. Toomer* assisted in the reductions of triangulations, and was afterwards detached for field duty. *Mr. J. E. Blankenship* aided *Assistant J. E. Hilgard* in the discussion of magnetic lines, reduced mean to apparent places of stars, and commenced reductions of triangulations. *Mr. J. T. Hoover* has acted as clerk to the division, and assisted in computing and making various diagrams. *Mr. S. Walker*, *Mr. J. L. Tilghman*, and *Mr. S. J. Hough*, were each temporarily attached to the division for a short time in miscellaneous computations.

2. TIDAL DIVISION.—Under the charge of *Assistant L. F. Pourtales* this division has fully maintained its high character during the past year. I have adverted to the progress made in the tidal discussions, under my immediate direction, in the introduction to my report; and a more extended notice of them will be found in *Mr. Pourtales'* reports in the Appendix Nos. 19 and 41. A statement of the observations made will also be found in them. The details of the records and ordinary office tidal computations, as reported by *Mr. Pourtales*, are in Appendix No. 19.

Mr. Avery has discussed the tides of Boston harbor, and deduced from them tables for the prediction of tides; he has also devoted much attention to the simplification of the methods of discussion. *Mr. Kincheloe* has been chiefly engaged in computations relating to the diurnal inequality on the Eastern and Western Coasts, and in miscellaneous work. *Mr. Fendall* has made numerous decompositions of tides by the graphical method; among them, a whole year of the tides of San Francisco; he also made numerous diagrams and miscellaneous computations. *Mr. Downes*, who joined the division in December, has computed the theoretical lunitidal intervals for San Francisco, and also some of the groups for cotidal lines of the Gulf of Mexico. *Mr. Evans* read off and reduced the self-registering observations until his detachment for field duty. *Mr. Blanchard* assisted in the same duty, and in ordinary reductions. *Messrs. Bassett*, *Walker*, and *Williams* were engaged, at intervals, in miscellaneous reductions.

3. DRAWING DIVISION.—This has continued under the charge of *Lieutenant J. C. Tidball, U. S. A., assistant.* Captain Benham reports that, notwithstanding the calls made upon this division for extra work, especially for that connected with the resurvey of New York bay and harbor for the Commissioners on Harbor Encroachments, this division has kept well up to the ordinary work in the preparation of first-class maps and charts, as well as of sketches for publication in the annual report. Good progress has been made on two off-shore charts of the Atlantic coast, one north and east, and the other south and west of that between Gay Head and Cape Henlopen; also, on one of the seacoast charts of Mississippi sound. The drawings of the sketches for my last annual report were all completed by the 3d of July of the present year, and it is expected that those of the present year will be ready by the close of February. A map of Central America, from materials furnished by the Committee of Foreign Affairs of the United States Senate, was also compiled in this division by request of the State Department. The work of the year has been added to the Congress map. The annual sketches have been made anew upon uniform scales, and a map of the coast for the Light-house Board has made considerable progress. During the year, *Captain A. A. Gibson, U. S. A.*, to whom especially had been assigned, under my own immediate direction, the preparation of projects or plans of maps, was relieved from Coast Survey service, and this work was assigned to *A. Boschke, Esq.*, assisted by *Mr. A. E. Hartman.* It has been much interrupted by the necessary absence of Mr. Boschke on duty for the New York Harbor Commissioners, but has made reasonable progress in a general system, the details for which are nearly ripe in most of the sections of the coast. Captain Gibson had served the Coast Survey efficiently, and I regretted much to lose his services and judgment in matters relating to the Drawing Division.

Assistant W. M. C. Fairfax has been occupied on topographic and hydrographic reductions of the first class; *Assistant M. J. McClery* and *Mr. Joseph Welch* in the first-class reductions of topography; *Mr. J. J. Ricketts,* on fine hydrographic reductions and verification; *Mr. A. Balbach,* on the same during part of the year; *Mr. L. D. Williams* on reductions of hydrography and topography of the first and second classes; *Messrs. A. Lindenkohl, J. R. Key, W. T. Martin,* and *F. Fairfax* on hydrographic reductions of the second class; *Messrs. W. P. Schultz, A. E. Hartman,* and *P. Witzel* (the two latter part of the year only) principally on progress sketches, projects and projections for field parties; *Mr. W. Fairfax* on sketches; *Messrs. B. Hooe, jr., H. McCormick,* and *S. B. Linton* on the miscellaneous work of the division.

Captain Benham refers in strong terms to the services of Lieutenant J. C. Tidball in charge of this division.

4. ENGRAVING DIVISION.—This was under the charge of *Lieut. J. C. Clark, U. S. A., assistant,* until May of this year, and since under that of *Lieut. Rufus Saxton, U. S. A.* The large first-class maps of Boston harbor and Mobile bay are included in the finished work of this year, making an average of nearly five first-class maps per year, for several years, besides annually some thirty other maps and charts.

The first-class topography, hydrography, and lettering have been executed by *Messrs. G. McCoy, F. Dankworth, A. Rolle, J. Knight, J. V. N. Throop,* and *G. B. Metzeroth. Messrs. A. Blondeau* and *A. Sengteller* have been employed a portion of the year only upon first-class work. The topography, hydrography, and lettering, generally have employed *Messrs. A. Maedel, J. C. Kondrup, A. Petersen,* and *J. J. Knight,* during the whole year. *Messrs. H. S. Barnard, W. Langran, W. Ogilvie,* and *R. T. Knight,* have been employed a portion of the year only. The preliminary charts and sketches have been executed by apprentices *J. W. Bradley, R. F. Bartle, F. W. Benner, W. A. Thompson,* and *W. Rose,* the latter being employed the greater portion of the year.

Captain Benham acknowledges, with high praise, the exertions of *Edward Wharton, Esq.,* the clerk of this division, upon whom its charge has devolved during a portion of the year, in consequence of the sickness of Lieutenant Saxton, stating that the force had been "faithfully, laboriously, and judiciously employed."

5. ELECTROTYPE DIVISION.—Captain Benham reports that, in this division, "still under the direction of *Mr. George Mathiot,* a much larger amount of work has been accomplished than in any former year, besides, as always heretofore, some successful experimental results. Some thirty-two alto plates, including seven of the thin bassos, and the same number of plates for printing have been prepared, and five other large plates have been rearranged, joined, or altered, making sixty-nine in all, directly needed for printing purposes; while some thirty other electrotype plates are reported as having been made for uses in experiments of various kinds."

The successful experiment of printing from thin electrotype plates has been already referred to in the introduction to my report. Captain Benham says further:

"Important additions to the electrotype apparatus have been made during the year, as much nearly as the size of the building now in use will permit. The experiments in photo-electric or "actino" engraving have been continued, and with further successful results; and preparations are making for an "actino" engraved plate, of a size about thirteen inches square. Mr. Mathiot appears confident of eventual success in the art of engraving by this process; and the important inventions that have, from year to year, been developed by his ingenuity and industry, lead me to hope for the desirable result he anticipates."

Mr. R. W. Patterson has assisted Mr. Mathiot in the electrotyping and records of the division.

6. MISCELLANEOUS.—(*a.*) *Printing.* "The printing has been executed, as heretofore, by *Mr. O'Brien,* with *Mr. Rutherdale* as assistant, and all the maps which have been required for sale, or for gratuitous distribution to public institutions and others, as well as all that were necessary for office uses, have been prepared, amounting to about 34,700 copies in all, including in

this a new edition of about 400 sets of the fine maps of the work, on thin paper, for binding in volumes."

(*b.*) *Distribution of maps and reports.*—"The charge of the maps and the distribution of the reports have been continued with *Mr. V. E. King* during the past year, and by his report six finished maps, seven preliminary charts, and twenty-one sketches have been added to the publication list. There have been turned over to our agents for sale about three thousand copies of the charts of the work; and about eight thousand five hundred have been gratuitously distributed, under authority of the Treasury Department, to institutions and individuals, both in our own and foreign countries, making, with some hundreds required for the office, nearly 12,000 impressions usefully disposed of during the year. Over 6,100 copies of the annual report for 1854, and about 1,250 copies of those of previous years, have been, under the authority of Congress, distributed to libraries, institutions of learning, and to individuals in the different States; to Army and Navy libraries and officers; and to meet the extra calls made by members of Congress for this work. Nearly 500 copies have been presented to foreign governments and their literary and scientific institutions, and to their prominent citizens distinguished in such pursuits."

(*c.*) "The *Library and Archives* have continued under the care of *Mr. C. B. Snow.* The library now consists of 3,876 volumes—nearly every one relating directly or indirectly to the duties of the survey. Of these, 241 have been purchased during the past year, and 172 were presented by foreign governments, and by different scientific societies."

"By far the most important of these additions is the magnificent set of works published by the government of France, and presented to the Coast Survey office by order of Admiral Hamelin, the Minister of Marine, in return for some presents of our newly invented instruments, Coast Survey maps, reports, &c., which, by authority of the Treasury Department, were presented to the French government. This present to our library consists of seventeen folio volumes of splendid illustrations of various character, accompanying some sixty volumes of letterpress description of voyages made by the national vessels of France. In addition to these, we have received from the same source eleven large folio volumes of the charts published by the French Marine Department."

There has also been presented to the office, in return for sets of maps, reports, &c., presented to the British Ordnance Survey and Admiralty officers, a portfolio containing upwards of two hundred sheets of the beautiful maps of England, prepared by the Ordnance Survey.

(*d.*) "In the *Instrument Shop*, a large number of valuable instruments have been made for the survey, and a still greater number—in fact, nearly all that have required it—have been repaired, or altered, or rearranged by the force there employed."

"Among the more important instruments fabricated, are included one self-registering tide-gauge, ten deep-sea thermometers, two theodolites, and five stands for theodolites, two reconnoitering telescopes, two sounding instruments, seven three-armed protractors, one large circular protractor, four sectors, six beam compasses, three magnetic compasses, three plane-tables, four reducing frames, and a cylinder for magnetic observations."

"Among the instruments repaired, are twenty-eight theodolites, twenty-three plane-tables, eleven heliotropes, sixteen deep-sea thermometers, three transit instruments, thirty-seven sextants, nineteen telescopes, ten reconnoitering telescopes, seven ship compasses, six surveying compasses, four prismatic compasses, ten sounding instruments, six self-registering tide-gauges, two dip-circles, two zenith telescopes, three sectors, and three sets of base rods. A number of other instruments were repaired for field parties, and work has been done also for the engraving and drawing divisions."

(*e.*) "In the *Carpenter's Shop*, under *Mr. Yeatman*, the usual necessary labor has been performed, including, among many other things, the making of fourteen theodolite and plane-table stands, three barometer cases, a case for the Hardy clock, and some twenty other boxes to fit valuable instruments, such as heliotropes, transits, plane-tables, compasses, &c., with a large number of drawing and engraver's desks, tables, cases for maps, copper-plates, &c. In addition to these, nearly two hundred cases for maps have been painted and numbered. The Coast Survey buildings have been kept in repair; and the packing of instruments for field and hydrographic parties has been well performed."

Captain Benham commends highly, in his report, the services of *Assistants J. E. Hilgard and Charles A. Schott*, in charge of the computing division; of *Assistant L. F. Pourtales*, in charge of the tidal division; very specially the services of *Lieut. J. C. Tidball, U. S. A.*, in charge of the drawing division; of *Mr. G. A. Porterfield*, clerk of the same division; of *Lieuts. J. C. Clark and Rufus Saxton, U. S. A.*, in charge of the engraving division; and also specially those of *Mr. E. Wharton*, clerk of the division; of *Mr. G. Mathiot*, in charge of the electrotype division; of *Mr. C. B. Snow*, in charge of the archives and library; of *Mr. A. W. Russell*, the principal clerk of the assistant in charge; of *Mr. J. Vierbuchen*, chief instrument maker; and of *Mr. H. Yeatman*, chief carpenter.

Captain Benham also acknowledges the cordial co-operation of the General Disbursing Agent of the Coast Survey, *Samuel Hein, Esq.*, in all matters relating to the office.

Very acceptable service has been rendered during the year by *Lieut. W. D. Whiting*, of the Navy, in the revision of the office-work of the hydrography, and in preparing or revising the data for the published charts. Lieut. Whiting has also given advice in reference to the repairs of the Coast Survey vessels.

I have already, in the introduction, acknowledged the services of *Professor A. G. Pendleton, U. S. N.*, in the Gulf Stream and astronomical work, and of *Lieutenant E. B. Hunt*, of the Corps of Engineers, in the preparation of the index of memoirs and papers on subjects of science connected with the Coast Survey.

Samuel Hein, Esq., General Disbursing Agent of the survey, has continued to discharge the difficult and onerous duties assigned to him, with his usual facility and success.

In closing my report, I must also acknowledge the able and devoted services of my principal clerk, *W. W. Cooper, Esq.*, upon whom, by the new arrangement of the details of the Superintendent's office, additional duties have devolved, which he has discharged very successfully.

Respectfully submitted by

A. D. BACHE,
Superintendent U. S. Coast Survey.

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

APPENDIX.

APPENDIX No. 1.

Distribution of the parties of the Coast Survey upon the coast of the United States during the surveying season of 1855–'56.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION I.				
From Passamaquoddy bay to Point Judith, including the coast of Maine, N. Hampshire, Massachusetts, and Rhode Island.	No. 1	Geodetic, astronomical, and magnetic observations.	A. D. Bache, Superintendent; Geo. W. Dean, assistant; Lieut. J. D. Bingham, U. S. Army, assistant; Stephen Harris, sub-assistant; Edward Goodfellow, sub-assistant.	Saunders Station, Hancock county, Me.; occupied for connection between primary and secondary triangulation; astronomical, geodetic, and magnetic observations, at primary station on Mount Desert island, coast of Maine. (See also Section V.)
	2	Reconnaissance.	A. D. Bache, Superintendent; C. O. Boutelle, assistant; Lieut. J. C. Clark, U. S. Army, assistant; F. P. Webber, aid.	Reconnaissance for connecting site of verification base, on Epping plain, with adjacent stations in the primary triangulation. (See also Section V.)
	3	Secondary triangulation.	Lieut. A. W. Evans, U. S. Army, assistant; Benjamin Huger, jr., sub-assistant; G. E. Humphries, aid.	Kennebec river, in the vicinity of Bath; Sheepscot river, and stations in Casco bay, for continuance of triangulation. (See also Sections V and VI.)
	4	Topography.	I. Hull Adams, assistant; H. S. Duval, aid.	Plane-table survey of southern part of Small Point peninsula, Me.; and of the mouth of Kennebec river, including Seguin and other adjacent islands. (See also Section III.)
	5	Topography.	A. W. Longfellow, assistant; N. S. Finney, aid.	Detailed topography of the city of Portland, for finished chart of Portland harbor. (See also Section V.)
	6	Topography.	R. M. Bache, assistant.	Completion of plane-table survey of Duxbury, Mass., and extension of topography towards Marshfield. (See also Section VIII.)
	7	Topography.	C. T. Iardella, sub-assistant.	Coast of Cape Cod peninsula, from Orleans to Nausett Centre light, and re-survey of Monomoy Point. (See also Section VI.)
	8	Topography.	H. L. Whiting, assistant.	Resurvey and determination of changes in shore line of Muskeget channel. (See also Sections II and III.)
	9	Hydrography.	Lieutenant Commanding Stephen D. Trenchard, U. S. Navy, assistant.	Hydrography of Casco bay, extended from Great Jebeig island westward to join former work; soundings at the entrance to Kennebec river, Me., and supplementary hydrography between Annis Squam and Ipswich, coast of Massachusetts. (See also Sections V and VI.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION I—(Continued.)	No. 10	Hydrography.	Commander H. S. Stellwagen, U. S. Navy, assistant.	Deep-sea soundings from Cape Cod peninsula extending to longitude 66° 30′ west, and completion of hydrography from Monomoy to Race Point (Cape Cod); in-shore hydrography from Scituate to Plymouth; hydrography of Cape Cod bay completed, and additional lines of soundings off Cape Ann.
	11	Hydrography.	Lieutenant Commanding C. R. P. Rodgers, U. S. Navy, assistant.	Approaches to Nantucket sound completed, including soundings of Great Round shoal and adjacent sand ridges, and the middle and southern part of Nantucket sound to the eastward of Nantucket light-boat; resurvey of Horse Shoe, Eldridge's, and Wreck shoals. Supplementary hydrography in northeastern part of Nantucket sound; also northward from Holmes' Hole and on the Middle Ground, (Vineyard sound,) and survey of Cotamy bay, adjoining Edgartown harbor. (See also Section II.)
	12	Tidal observations.	------------	Observations with self-registering gauge continued at Boston dry dock.
SECTION II. From Point Judith to Cape Henlopen, including the coast of Connecticut, N York, and N. Jersey, and shore of Pennsylvania and Delaware.	No. 1	Secondary triangulation.	Edmund Blunt, assistant; Lieut. J. C. Clark, U. S. Army, assistant, (part of season;) Charles Ferguson, sub-assistant; G. H. Bagwell, sub-assistant.	Determination of points in New York city and vicinity for topographical work of Commissioners on Harbor Encroachments.
	2	Secondary triangulation.	Edmund Blunt, assistant; Lieut. A. H. Seward, U. S. Army, assistant; Lieut. A. P. Hill, U. S. Army, assistant.	Triangulation of Hudson river, between Albany and New Baltimore.
	3	Topography.	F. H. Gerdes, assistant; J. G. Oltmanns, sub-assistant; Chas. H. Boyd, aid.	Topography of shores of East river, from Harlem river to Throg's Neck, completed; and of Long Island, from Brooklyn to Jamaica and Flushing; also topography of western shore of Hudson river, above Hoboken, and of eastern shore, above New York city, extending to Palisade Point; executed for Commissioners on Harbor Encroachments. (See also Sections VII and VIII.)
	4	Topography.	S. A. Gilbert, assistant; J. A. Sullivan, sub-assistant; Malcolm Seaton, sub-assistant; W. S. Gilbert, aid; F. W. Alexander, aid, (part of season.)	Topography completed of western end of Long Island, and of southern side, including Jamaica bay and islands; also resurvey of Rockaway inlet and interior, with the towns of Flatlands, Centreville, Gravesend, New Utrecht, Flatbush, Gowanus, New Lots towards Jamaica, and Fort Hamilton, for Commissioners on Harbor Encroachments. (See also Section IX.)
	5	Topography.	H. L. Whiting, assistant; F. W. Dorr, aid.	Finished topography of the shores and details of the interior of Staten island, for Commissioners on Harbor Encroachments. (See also Sections I and III.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION II—(Continued.)	No. 6	Topography.	A. M. Harrison, assistant; P. R. Hawley, aid; W. H. Dennis, aid, (part of season.)	Finished plane-table resurvey of southern shores of Raritan bay and Sandy Hook bay, from mouth of Raritan river to Shrewsbury inlet, including the highlands of Navesink, and Sandy Hook, for Commissioners on Harbor Encroachments. (See also Sections VI and VII.)
	7	Topography.	A. Boschke.	Details of topography: wharves of New York city and Brooklyn, and shores of Harlem river and its dependencies.
	8	Topography.	A. S. Wadsworth, assistant.	Shores of Hudson river, between Albany and New Baltimore. (See also Sec. IV.)
	9	Hydrography.	Lieutenant Commanding C. R. P. Rodgers, U. S. Navy, assistant.	Resurvey of harbor inside of Sandy Point, near Stonington, Conn. Re-examination for light-house sites in Delaware bay. (See also Section I.)
	10	Hydrography.	Lieutenant Commanding T. A. Craven, U. S. Navy, assistant.	Hydrography completed, of New York bay and harbor—from Light Ship to Throg's Point, including Harlem river, Harlem Kills, and Little Hell Gate; for Commissioners on Harbor Encroachments. (See also Section VI.)
	11	Hydrography.	Lieutenant Comd'g Richard Wainwright, U. S. Navy, assistant.	Hydrography of Hudson river, between Albany and New Baltimore. (See also Section III.)
	12	Tidal observations.	Lieut. W. P. Trowbridge, U. S. Engineers, assistant; Gustavus Würdemann.	Investigation of the tides in Hudson river, using stations at Governor's island, Dobb's Ferry, Verplanck's Point, West Point, Poughkeepsie, Tivoli, Stuyvesant, Castleton, and Albany. (See also Sections X and XI.)
	13	Tides and currents.	Henry Mitchell, sub-assistant; W. G. Williams, aid.	Tides and currents of Newark bay, Kill van Kull, and Arthur's Kill; and investigation of currents at Sandy Hook and in docks of New York city, for Commissioners on Harbor Encroachments. Tides and currents of Passaic river.
SECTION III. From Cape Henlopen to Cape Henry, including the coast of part of Delaware, and the coast of Maryland and Virginia.	No. 1	Secondary triangulation.	John Farley, assistant; Charles Ferguson, sub-assistant, (part of season;) J. P. Farley aid.	James river, Va., from Upper Brandon station, downwards, to Jamestown and Hog island.
	2	Secondary triangulation.	Lieutenant J. P. Roy, U. S. Army, assistant.	York river, Va., from entrance connecting with work on Chesapeake bay, and extending upwards to Purtan island and Moody's wharf.
	3	Topography.	H. L. Whiting, assistant.	Verification of topography on east side of Elk river, Md., and on both shores of Rappahannock river, Va., extending six miles below Tappahannock. (See also Sections I and II.)
	4	Topography.	John Seib, assistant; W. H. Dennis, aid.	Survey of mouths of the Potomac and Rappahannock rivers, including adjacent shore of Chesapeake bay; topography of interior, near Wolf Trap, and on Piankatank river, completed, with numerous creeks and water-courses (See also Section V.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION III—(Continued.)	No. 5	Topography.	Geo. D. Wise, assistant; F. F. Nes, aid.	Plane-table survey of main coast and of islands bordering Chincoteague inlet, Va. (See also Section VII.)
	6	Topography.	I. Hull Adams, assistant.	Shores of Rappahannock river, Va., between line "Punch Bowl—Dowaman" and line joining "Jones" Station and "Upper Spindle." (See also Section I.)
	7	Hydrography.	Lieutenant Comd'g Richard Wainwright, U. S. Navy, assistant.	Finished hydrography of Rappahannock river, Va, between Accaceek Point and stations "Punch Bowl"—"Downman," with accompanying tidal observations. (See also Section II.)
	8	Hydrography.	Lieutenant Comd'g John J. Almy, U. S. Navy, assistant.	Completion of hydrography in Tangier sound and its dependencies, Chesapeake bay, and examination of work in the vicinity of Cape Henry. (See also Section IV.)
	9	Hydrographic reconnaissance.	Lieutenant Comd'g J. N. Maffitt, U.S. Navy, assistant.	Extension of soundings in James river, upwards, from Hog island to mouth of Chickahominy river, Va. (See also Section V.)
	10	Magnetic observations.	Chas. A. Schott, assistant; J. L. Tilghman, aid.	Determination of magnetic declination, dip, and intensity, at Cape Henlopen light, and Dagsborough, Del.; Oxford, Merton's Landing, and Baltimore, Md.; Washington, D.C.; and at Snead, Jaynes, Scott, Fredericksburg, Richmond, Cape Charles, Old Point Comfort light, Norfolk, and Cape Henry light, Va.
SECTION IV.				
From Cape Henry to Cape Fear, including part of the coast of Virginia and coast of North Carolina.	No. 1	Telegraphic observations.	George W. Dean, assistant; Edward Goodfellow, sub-assistant; F. M. McIver, aid, (part of season;) McLane Tilton, aid.	For difference of longitude between Wilmington, N. C., and Columbia, S. C. (See also Section V.)
	2	Secondary triangulation.	J. J. S Hassler, assistant.	Connection made with Cape Henry east and light-house, by triangulation extended from the northern part of Back bay along the seacoast of Virginia.
	3	Triangulation and topography.	A. S. Wadsworth, assistant; J. Mechan, aid; H. S. Duval, aid.	Triangulation of seacoast of North Carolina, from stations "Skeleton"—"Macawber," southward, to Rich inlet; and topography from New river, southward, to Stump inlet. (See also Section II.)
	4	Hydrography.	Lieutenant Comd'g John J. Almy, U. S. Navy, assistant.	Off-shore hydrography of coast of North Carolina completed, from Cape Hatteras, southward, to South Portsmouth, N. C. (See also Section III.)
SECTION V.				
From Cape Fear to St. Mary's river, including the coast of South Carolina & Georgia.	No. 1	Astronomical, telegraphic, and magnetic observations.	Dr. B. A. Gould, jr., assistant; George W. Dean, assistant; Edward Goodfellow, sub-assistant.	Telegraphic difference of longitude between Columbia, S. C., and Wilmington, N. C.; also between Macon, Ga., and Montgomery, Ala. Observations for latitude and magnetic elements at Montgomery. (See also Sections I and IV.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION V—(Continued.)	No. 2	Primary and secondary triangulation.	C. O. Boutelle, assistant; Lieut. Rufus Saxton, U. S. Army, assistant; F. P. Webber, aid.	Continuation of triangulation on South Edisto river, and extension of work into St. Helena sound. (See also Section I.)
	3	Secondary triangulation and topography.	C. P. Bolles, assistant; G. H. Bagwell, sub-assistant; W. S. Edwards, aid.	Triangulation and topography of coast of North Carolina, between Cape Fear river and Lockwood's Folly entrance, completed, including the approaches to both.
	4	Secondary triangulation and topography.	A. W. Longfellow, assistant; N. S. Finney, aid.	St. Simon's entrance and sound completed, in connection with triangulation of Brunswick harbor and Turtle river, Ga., extending to Blythe island. Topography commenced. (See also Section I.)
	5	Secondary triangution and reconnaissance.	Lieut. A. W. Evans, U. S Army, assistant; F. M. McIver, aid.	Measurement of preliminary base and triangulation of Sapelo sound and entrance, including Sapelo river and vicinity, Ga. (See also Sections I and VI.)
	6	Topography.	John Seib, assistant; W. H. Dennis, aid.	Shores of Dawho river, S. C., from the confluence of South Edisto and Pon Pon rivers to within a few miles of its mouth. Shore-line of St. Helena sound, connecting with outer coast of South Carolina, contiguous to the Hunting islands, and extending nearly to Port Royal entrance. Verification of topography in Winyah bay and Georgetown harbor, S. C. (See also Section III.)
	7	Hydrography.	Lieutenant Commanding J. N. Maffitt, U. S. Navy, assistant.	Resurvey of ship channels over Georgetown bar, S. C., with shore-line of North island and others in Winyah bay. Maffitt's channel resurveyed. Soundings completed off Rattlesnake shoal. In-shore hydrography of coast of South Carolina completed from "Palmetto" signal (above N. Edisto) to St. Michael's creek, including resurvey of North Edisto entrance and hydrography of the harbors and bars of South Edisto and St. Helena sound, with supplementary work at the mouth of Broad river and entrance to Port Royal sound. (See also Section III.)
	8	Hydrography.	Lieutenant Commanding Stephen D. Trenchard, U. S. Navy, assistant.	St. Simon's sound, the bar, and approaches, and hydrography of Brunswick harbor, Ga., completed, including part of Turtle river beyond Brunswick. (See also Sections I and VI.)
		Tidal observations.	Gustavus Würdemann.	Station on St. John's river for tides, and for tidal currents on St. John's bar, Fla.
		Inspection.	A. D. Bache, Superintendent	Telegraph operations at Macon, Ga., and Montgomery, Ala. Triangulation, topography, and hydrography, near Brunswick. Triangulation and tidal observations at St. Mary's. Triangulation at Sapelo entrance, Ga.

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION V—(Continued.)				
Gulf Stream.	No. 1	Soundings, and temperature observations.	Commander B. F. Sands, U. S. Navy, assistant.	Soundings midway between the coast and inner edge of the Gulf Stream, from off Cape Fear to the latitude of St. Simon's Sound, Ga., and from the mouth of Savannah river to Cape Cañaveral, Fla. Temperature stations in the axis of the Stream, from off Cape Lookout, extended northward to Cape Hatteras. (See also Section VIII.)
SECTION VI.				
From St. Mary's river to St. Joseph's bay, including the eastern and part of the western coast of Florida.	No. 1	Astronomical observations.	Edward Goodfellow, sub-assistant; McLane Tilton, aid.	For determination of latitude at Fernandina, Fla., near the entrance to St. Mary's river, boundary between Georgia and Florida. (See also Sections I and V.)
	2	Triangulation	Lieut. A. W. Evans, U. S. Army, assistant; F. M. McIver, aid.	Completion of work on St. Mary's river and Cumberland sound, in connection with the triangulation of Amelia river, Bell's river, and Jolly river, Fla. Measurement of verification base, near Jacksonville, and its connection with the triangulation of St. John's river, Fla. (See also Sections I and V.)
	3	Secondary and tertiary triangulation.	Lieut. A. H. Seward, U. S. Army, assistant; Stephen Harris, sub-assistant, (part of season;) C. B. Baker, aid.	Erection of signals from Cape Sable base, southward and eastward, to Centre key, and triangulation of outer keys carried from Horse Shoe and Little Pine keys, eastward, to Jacobs' harbor. (See also Sections I and II.)
	4	Triangulation	John Rockwell, sub-assistant; J. A. Sullivan, sub-assistant, (part of season;) S. J. Hough, aid.	Triangulation of Florida keys, eastward, from line "Johnston"—"Loggerhead," and extended to "Little Pine"—"Middle Summerland." Provision of screw-pile beacon for the "Elbow," Florida reef. (See also Sections II and IX.)
	5	Topography	A. M. Harrison, assistant; P. R. Hawley, aid.	Topography of shores of St. John's river, Fla., completed to Winters' Point, above and including the town of Jacksonville and its environs. (See also Sections II and VII.)
	6	Topography	C. T. Iardella, sub-assistant; F. W. Alexander, aid.	Sugar Loaf, Cudjoe key, Loggerhead key, Summerland key, and small detached keys on Florida reef, surveyed and marked in sections for General Land Office. (See also Section I.)
	7	Topography	S. A. Wainwright, sub-assistant; J. L. Tilghman, aid.	Topography of Johnston key and Sawyer's key, and of two other large and numerous smaller keys lying between the Pine islands and Key West, executed, and sections marked for General Land Office.
	8	Hydrography	Lieutenant Commanding T. A. Craven, U. S. Navy, assistant.	Hydrography of Florida reef extended from Grecian shoal, southward and westward, to French reef, and from Eastern Sambo to Loggerhead Key. (See also Section II.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION VI—(Continued.)	No. 9	Hydrography.	Lieutenant Commanding S. D. Trenchard, U. S. Navy, assistant.	Soundings completed at the entrance to Cumberland sound, including Fernandina harbor and Amelia river. Re-examination of St. Mary's bar and hydrography of river carried upwards beyond St. Mary's, with tidal and current observations. (See also Sections I and V.)
SECTION VII.				
From St. Joseph's bay to Mobile bay, including part of the western coast of Florida, and the coast of Alabama.	No. 1	Secondary triangulation and astronomical observations.	F. H. Gerdes, assistant; J. G. Oltmanns, sub-assistant; C. H. Boyd, aid.	Measurement of preliminary base and extension of secondary triangulation over Pensacola bay, including Pensacola city, with observations for latitude and azimuth at the navy yard, Pensacola. (See also Sections II and VIII.)
	2	Triangulation.	Spencer C. McCorkle, sub-assistant.	Measurement of preliminary base and triangulation of the harbor of St. Mark's; measurement of preliminary base at Apalachicola and triangulation of St. George's sound, including Apalachicola harbor, nearly completed.
	3	Triangulation.	Benj. Huger, jr., sub-assistant; G. E. Humphries, aid.	Triangulation from Cedar keys, (Depot key,) extended eastward to Grassy Point, on Waccasassa bay, western coast of Florida. (See also Section I.)
	4	Topography.	F. H. Gerdes, assistant; J. G. Oltmanns, sub-assistant; R. E. Halter, aid; C. H. Boyd, aid.	Survey of entrance to Pensacola bay, and topography of the shores upwards to Escambia bay. (See also Sections II and VIII.)
	5	Topography.	Geo. D. Wise, assistant.	Plane-table survey of St. Mark's river and St. George's sound completed; survey of shores of Apalachicola bay nearly completed. (See also Section III.)
	6	Topography.	A. M. Harrison, assistant; P. R. Hawley, aid.	Topography of Cedar keys extended eastward to Waccasassa river, and including reefs in Waccasassa bay; plane-table reconnaissance of the mouths of Waccasassa & We-thlocco-chee rivers; and examination of Crystal river and Homosassa river, western coast of Florida. (See also Sections II and VI.)
	7	Hydrography.	Lieutenant Comd'g O. H. Berryman, U. S. Navy, assistant, (part of season;) Lieutenant Comd'g John K. Duer, U. S. Navy, assistant.	Supplementary hydrography off the entrance and including the bar and harbor of St. Andrew's; hydrography of St. Mark's river and harbor; continuation of the hydrography of Cedar keys and approaches; soundings in Waccasassa bay and Crystal river offing extended to northeastern edge of St. Martin's reef.
SECTION VIII.				
From Mobile bay to Vermilion bay, including the coast of Alabama, Mississippi, and part of Louisiana.	No. 1	Primary and secondary triangulation, and astronomical observations.	J. E. Hilgard, assistant; Stephen Harris, sub-assistant; Joseph S. Harris, aid.	Continuation of the primary triangulation to Cat Island light, Pitcher Point, and to the Chandeleur islands; completion of secondary triangulation of Lake Pontchartrain; observations of azimuth at Cat island.
	2	Secondary triangulation and topography.	J. E. Hilgard, assistant; J. G. Oltmanns, sub-assistant; R. E. Halter aid.	Continuation of secondary triangulation and topography to south end of Chandeleur islands.

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION VIII—(Continued.)	No. 3	Secondary triangulation and topography.	F. H. Gerdes, assistant; J. G. Oltmanns, sub-assistant; R. E. Halter, aid; C. H. Boyd, aid.	Completion of secondary triangulation in Atchafalaya bay, from Belle isle to Côte Blanche bay; and topography of shores of Atchafalaya bay. (See also Sections II and VII.)
	4	Topography.	R. M. Bache, assistant.	Plane-table survey of Pearl River island and vicinity, and shore-line of part of Lake Borgne, included between the Rigolets and Chef Menteur. (See also Section I.)
	5	Hydrography.	Commander B. F. Sands, U. S. Navy, assistant.	Northern shore of Mississippi sound completed, from line joining Cat island and Point Blanc—westward to East Pearl river, including St. Louis bay and Grand Island passage, into Lake Borgne, and southward to line from Cat Island light-house to St. Joseph's island. Lines of deep-sea soundings in Gulf of Mexico: from N. W. passage (Key West) to delta of Mississippi river; eastward from Pass à Loutre to middle meridian of Horn island, and thence north to off-shore soundings: from Pensacola bay southwest to latitude of south end of Chandeleur sound, and thence N.W. by W. to entrance of sound; and line from Chandeleur sound to N.W. passage, (Key West.) (See also Gulf Stream.)
SECTION IX.				
From Vermilion bay to the southwestern boundary, including part of the coast of Louisiana and the coast of Texas.	No. 1	Triangulation and topography.	S. A. Gilbert, assistant; Malcolm Seaton, sub-assistant.	Triangulation of lower part of Matagorda bay, Texas, and extension into Lavacca and Palacios bays; topography of main land completed north and south of Matagorda, from Lake Austin to Palacios bay, and of outer peninsula to Decros Point. (See also Section II.)
	2	Topography.	J. A. Sullivan, sub-assistant, (part of season.)	Plane-table survey of peninsula adjacent to the eastern extremity of Matagorda bay between Cany creek and "Smith" station, and survey of the interior, including part of Live Oak bayou, part of Lake Austin, and extending northward to a point above "Kenner" signal, on Cany creek. (See also Sections II and VI.)
	3	Hydrography.	Lieutenant Commanding Edwin J. De Haven, U. S. Navy, assistant.	Hydrography of coast of Texas, from Jupiter station southward and westward to Bath station, head of Matagorda bay.
SECTION X.				
Western coast of the United States from the southern boundary to the 42d parallel, including the coast of California.	No. 1	Primary, secondary, and tertiary triangulation.	G. A. Fairfield, assistant.	Extension of primary triangulation, northward of San Francisco, from Ballenas bay to Russian river. Secondary triangulation of Tomales bay and Bodega bay.
	2	Triangulation.	W. E. Greenwell, assistant; P. C. F. West, aid.	Triangulation of main between San Pedro and Point Duma, and of islands in Santa Barbara channel, continued.

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION X—(Continued.)	No. 3	Topography.	Augustus F. Rodgers, sub-assistant; David Kerr, aid.	Plane-table survey of northern shore of San Pablo bay, Mare island strait, Karquines strait, San Antonio creek, and eastern shore of San Francisco bay, north of the mouth of San Antonio creek.
	4	Topography.	W. M. Johnson, sub-assistant; C. M. Bache, aid.	Topography of main shore of Santa Barbara channel, between Santa Clara river and Point Mugu.
	5	Hydrography.	Commander James Alden, U. S. Navy, assistant.	Hydrography of San Pablo bay, Mare island strait, San Diego bay, and False bay, completed. Survey of Cortez shoal completed, and hydrographic reconnaissance of southeastern end of San Clemente island. Hydrography continued in Santa Barbara channel, and between Monterey bay and San Francisco entrance, with deep-sea temperatures. (See also Section XI.)
	6	Hydrography.	Lieutenant Commanding Richard M. Cuyler, U. S. Navy, assistant.	Observations on the currents of Santa Barbara channel, including examination of currents outside of and between the Santa Barbara islands.
SECTION XI.				
Western coast of the United States from the 42d parallel to the northern boundary, including the coast of Oregon and Washington Territories.	No. 1	Triangulation and astronomical and magnetic observations.	George Davidson, assistant; James S. Lawson, sub-assistant.	Measurement of preliminary base at Port Townshend. Triangulation of Admiralty inlet, and extension of work towards the Straits of Fuca, Rosario strait, Hood's canal, and Puget's Sound. Observations for azimuth, and of occultations for longitude at Point Hudson.
	2	Topography.	James S. Lawson, sub-assistant.	Topography of Port Townshend and Port Gamble, Apple cove and Murden's cove, completed. Plane-table survey commenced at entrance of Hood's canal.
	3	Hydrography.	Commander James Alden, U. S. Navy, assistant.	Reconnaissance of Blakely harbor, W. T. Deep-sea temperatures off the coast of Oregon and Washington Territories. (See also Section X.)
SECTIONS X, XI.				
The coast of California, and Oregon and Washington Territories.		Tides.	Lieut. W. P. Trowbridge, U. S. Engineers, assistant.	Completion of tidal observations, except at permanent stations.
			Lieut. N. F. Alexander, U. S. Engineers.	Charge of permanent tidal stations at San Diego and San Francisco, (Section X,) and at Astoria, (Section XI.)

APPENDIX No. 2.

List of Army officers on Coast Survey duty March 1, 1856.

Officers.	Rank.	Date of attachment.
Henry W. Benham	Captain engineers	April 1, 1853
William R. Palmer	Captain topographical engineers	March 2, 1852
Joseph C. Clark, jr.	First lieutenant 4th artillery	January 7, 1854
Ambrose P. Hill	First lieutenant 1st artillery	November 23, 1855
John C. Tidball	First lieutenant 2d artillery	September 6, 1854
Augustus H. Seward	First lieutenant 5th infantry	December 11, 1851
Edward B. Hunt	First lieutenant engineers	May 5, 1851
William P. Trowbridge	First lieutenant engineers	April 18, 1851
Rufus Saxton	First lieutenant 4th artillery	December 25, 1855
James P. Roy	First lieutenant 2d infantry	October 7, 1853
Andrew W. Evans	Second lieutenant 7th infantry	November 10, 1852

APPENDIX No. 2 bis.

List of Army officers on Coast Survey duty September 1, 1856.

Officers.	Rank.	Date of attachment.
Henry W. Benham	Captain engineers	April 1, 1853
James H. Simpson	Captain topographical engineers	June 24, 1856
Joseph C. Clark, jr	First lieutenant 4th artillery	January 7, 1854
Ambrose P. Hill	First lieutenant 1st artillery	November 23, 1855
John C. Tidball	First lieutenant 2d artillery	September 6, 1854
Augustus H Seward	First lieutenant 5th infantry	December 11, 1851
Edward B. Hunt	First lieutenant engineers	May 5, 1851
William P. Trowbridge	First lieutenant engineers	April 18, 1851
Rufus Saxton	First lieutenant 4th artillery	December 25, 1855
James P. Roy	First lieutenant 2d infantry	October 7, 1853
Judson D. Bingham	First lieutenant 2d artillery	November 10, 1852
Andrew W. Evans	Second lieutenant 7th infantry	March 22, 1856

APPENDIX No. 3.

List of Navy officers on Coast Survey duty March 1, 1856.

Vessel.	Locality of service.	Officers.	Rank.	Date of attachment.
	Office work (Sect. I)	Henry S. Stellwagen	Commander	October 22, 1852
		K. R. Breese	Lieutenant	July 10, 1855
		C. R. P. Rodgers	Lieutenant commanding	July 7, 1855
		Thos. T. Houston	Lieutenant	May 31, 1855
	Office work (Sect. II)	Richard Wainwright	Lieutenant commanding	January 31, 1848
		J. B. Stewart	Lieutenant	November 15, 1852
		D. P. McCorkle	do	March 6, 1855
		W. G. Temple	do	June 5, 1855
		Thos. C. Eaton	do	July 23, 1852
	Office work (Sects. III and IV.)	John J. Almy	Lieutenant commanding	March 12, 1851
		R. D. Minor	Lieutenant	April 19, 1855
		Albert Allmand	do	March 28, 1855
Schooners Crawford, Gallatin, and Bancroft.	Sections III and V	John N. Maffitt	Lieutenant commanding	May 9, 1843
		Hunter Davidson	Lieutenant	January 17, 1852
		S. B. Luce	do	May 18, 1854
		R. Chandler	do	July 10, 1855
		D. L. Braine	do	October 28, 1855
		C. H. Cushman	Master	June 13, 1855
Schooner Bowditch	Sections V and VI	Stephen D. Trenchard	Lieutenant commanding	March 1, 1853
		F. A. Roe	Lieutenant	February 21, 1856
Steamer Corwin and tender.	Section VI	T. A. Craven	Lieutenant commanding	November 27, 1850
		J. C. Febiger	Lieutenant	December 3, 1851
		John Lee Davis	do	November 24, 1854
		W. T. Truxtun	do	July 19, 1854
		Jas. H. Rochelle	do	July 11, 1855
		E. K. Owen	do	December 4, 1855
		T. Le P. Cronmiller	Assistant surgeon	November 23, 1853
Schooner Varina	Section VII	Otway H. Berryman	Lieutenant commanding	December 8, 1853
		John K. Duer	Lieutenant	August 1, 1855
		S. L. Breese	do	October 11, 1854
		C. H. Greene	do	October 22, 1855
		W. T. Glassell	do	October 22, 1855
		F. A. Walke	Assistant surgeon	October 22, 1855
Steamer Walker	Section VIII	B. F. Sands	Commander	May 14, 1850
		W. M. Gamble	Lieutenant	September 18, 1855
		H. N. Crabb	do	August 23, 1855
		Jas. Parker, jr.	do	September 19, 1855
		J. C. Coleman	Assistant surgeon	December 2, 1855
Schooner Arago	Section IX	E. J. De Haven	Lieutenant commanding	November 12, 1855
		John Kell	Lieutenant	November 13, 1855
		James H. Gillis	do	October 18, 1855
		De Grasse Livingston.	Master	October 18, 1855
		Charles Martin	Passed assistant surgeon	October 20, 1855
Steamer Active and schooner Ewing.	Sections X and XI	James Alden	Commander	May 18, 1849
		J. S. Kennard	Lieutenant	May 6, 1852
		R. M. Cuyler	do	June 20, 1845
		S. S. Bassett	do	March 17, 1849
		Edw. E. Stone	do	March 29, 1854
		P. C. Johnson	do	July 20, 1854
		J. M. Browne	Assistant surgeon	May 10, 1855
	Office	W. D. Whiting	Lieutenant	July 30, 1853
	Do	A. G. Pendleton	Professor of mathematics.	May 8, 1848

APPENDIX No. 3 bis.

List of Navy officers on Coast Survey duty September 1, 1856.

Vessel.	Locality of service.	Officers.	Rank.	Date of attachment.
	Office work (Sect. VI)	John C. Febiger	Lieutenant	December 3, 1851
	Office work (Sect. VII)	John K. Duer	Lieutenant commanding	August 1, 1855
		S. Livingston Breese	Lieutenant	October 11, 1854
	Office work (Sect. VIII)	Benjamin F. Sands	Commander	May 14, 1850
		William M. Gamble	Lieutenant	September 18, 1855
	Office work (Sect. IX)	Edwin J. De Haven	Lieutenant commanding	November 12, 1853
		John Kell	Lieutenant	November 13, 1855
Steamer Bibb	Section I	Henry S. Stellwagen	Commander	October 22, 1852
		Hunter Davidson	Lieutenant	May 18, 1854
		K. Randolph Breese	do	July 10, 1855
		James G. Maxwell	Master	May 12, 1856
Schooner Gallatin and tender.	Section I	C. R. P. Rodgers	Lieutenant commanding	July 7, 1855
		Stephen B. Luce	Lieutenant	May 18, 1854
		Thomas T. Houston	do	May 31, 1855
		James H. Gillis	do	July 8, 1856
		De Grasse Livingston	Master	July 8, 1856
Steamer Vixen	Section I	Stephen D. Trenchard	Lieutenant commanding	March 1, 1853
		Francis A. Roe	Lieutenant	February 21, 1856
		John J. Cornwell	do	July 29, 1856
		Geo. F. Morrison	Master	July 29, 1856
		Robert L. May	do	July 29, 1856
Steamer Corwin	Section II	T. A. Craven	Lieutenant commanding	November 27, 1850
		William G. Temple	Lieutenant	June 5, 1855
		John Lee Davis	do	November 24, 1854
		Wm. T. Truxtun	do	July 19, 1854
		James H. Rochelle	do	July 11, 1855
		Elias K. Owen	do	December 4, 1855
		T. Le P. Cronmiller	Assistant surgeon	November 23, 1853
Schooner Nautilus	Section II	Richard Wainwright	Lieutenant commanding	January 31, 1848
		John B. Stewart	Lieutenant	November 15, 1852
		D. P. McCorkle	do	March 6, 1855
Schooner Crawford	Section III	John N. Maffitt	Lieutenant commanding	May 9, 1843
		Ralph Chandler	Lieutenant	July 10, 1855
		Daniel L. Braine	do	October 28, 1855
Steamer Hetzel	Sections III and IV	John J. Almy	Lieutenant commanding	March 12, 1851
		Robert D. Minor	Lieutenant	April 19, 1855
		William H. Ward	Master	April 10, 1856
		R. F. Mason	Passed assistant surgeon	April 10, 1856
Steamer Active and schooner Ewing.	Sections X and XI	James Alden	Commander	May 18, 1849
		Richard M. Cuyler	Lieutenant	June 20, 1845
		Simeon S. Bassett	do	March 17, 1849
		Philip C. Johnson, jr.	do	July 20, 1854
		J. M. Browne	Assistant surgeon	May 10, 1855
	Office	W. D. Whiting	Lieutenant	July 30, 1853
	Office	A. G. Pendleton	Professor of mathematics	May 8, 1848

APPENDIX No. 4.

List of assistant engineers United States Navy, on Coast Survey duty March 1, 1856.

Vessel.	Assistant engineers.	Rank.	Date of attachment.
Steamer Corwin	T. A. Jackson	Second assistant engineer	June 30, 1855
	James F. Lamdin	Third assistant engineer	June 30, 1854
	R. W. McCleery	do do	December 26, 1855
Steamer Walker	W. Holland	First assistant engineer	September 5, 1855
	J. M. Harris	Third assistant engineer	October 27, 1854
	W. M. Willet	do do	October 27, 1854
	John Hollins	do do	October 27, 1854
Steamer Active	N. C. Davis	First assistant engineer	February 22, 1853
	M. P. Jordan	Third assistant engineer	June 20, 1854
	John Howell	do do	June 20, 1854
Steamer Bibb	R. B. Quin	Second assistant engineer	May 28, 1855
Steamer Hetzel	W. C. Wheeler	do do	September 7, 1853

APPENDIX No. 4 bis.

List of assistant engineers United States Navy, on Coast Survey duty September 1, 1856.

Vessel.	Assistant engineers.	Rank.	Date of attachment.
Steamer Bibb	Henry H. Stewart	First assistant engineer	June 1, 1856
	W. H. Hunt	Third assistant engineer	May 15, 1856
Steamer Vixen	J. C. Hull	Second assistant engineer	May 6, 1856
	John S. Albert	Third assistant engineer	May 15, 1856
	W.M. Willet, jr	do do	October 27, 1854
Steamer Corwin	T. A. Jackson	First assistant engineer	June 30, 1855
	James F. Lamdin	Third assistant engineer	June 30, 1854
	R. W. McCleery	do do	December 26, 1855
Steamer Hetzel	W. C. Wheeler	First assistant engineer	September 7, 1853
	J. McElmell	Third assistant engineer	April 11, 1856
Steamer Active	N. C. Davis	First assistant engineer	February 22, 1853
	M. P. Jordan	Third assistant engineer	June 20, 1854
Steamer Walker	John Hollins	do do	October 27, 1854

APPENDIX No. 5.

List of information furnished by the Coast Survey during the year 1855–'56, *under authority of the Treasury Department.*

Date.	To whom communicated.	Information communicated.
1855.		
Nov. 5	Gen. T. Tilghman	Distance from Easton, Md., to City Hall, N. Y.
7	G. W. Blunt, Esq	Tracing of hydrographic surveys on the coast of South Carolina and Georgia in 1854 and 1855.
10	Franklin Institute Journal	Information relative to measurement of Florida bases.
20	Prof. Christopher Hansteen	Results of observations made for magnetic declination, dip, and intensity, at stations in vicinity of New York city.
Dec. 8	C. F. Henningson, Esq	Tracing of hydrographic survey of Cedar keys, Fla.
18	Hon. Howell Cobb	Tracing of reconnaissance of Brunswick harbor, Ga.
19	Solomon Cohen, Esq	Do. do.
26	G. P. Elliott, Esq	Tracing of hydrographic survey of Port Royal entrance and Beaufort river, S. C.
1856.		
Jan. 5	Lieut. J. C. Ives, Topographical Engineers	Tracing of hydrographic reconnaissance of Tampa bay, Fla.
8	Commander C. H. Kennedy, U. S. Navy	Distance between points in the vicinity of Norfolk, Va.
10	H. McCall, Esq	Tracing of topography of Bush, Gunpowder, and Middle rivers, Md.
15	John L. Hazzard, Esq	Tracing of Chandeleur islands, La
26	Egbert S. Viele, Esq	Tracing of shore-line of New Jersey.
Feb. 12	Messrs. Chubb Brothers	Tracing of line of soundings from Wharf Point to Poplar Point across Patapsco river, Md.
12	E. C. Anderson, Esq	Tracing of reconnaissance of Brunswick harbor, Ga.
15	Hon. E. C. Cabell	Tracing of hydrographic survey of Ocilla river, Fla.
20	G. W. Blunt, Esq	Tracing of additional soundings in Nantucket sound.
22	E. C. Anderson, Esq	Tracing of Savannah river from entrance to head of Argyle island, Ga.
26	War Department	Tracing of hydrographic survey of Olympia harbor, Washington Territory.
26	do	Tracing of hydrographic survey of Steilacoom harbor, Washington Territory.
March 5	Engineer Bureau	Copy of chart of St. Mary's bar and Fernandina harbor, Fla.
10	Henry E. Pierrepont, Esq	Tracing of topography of Newport and vicinity, R. I.
15	Richard Cromwell, Esq	Tracing of hydrography of part of Patapsco river, near Fort McHenry, Md.
17	G. W. Richards, Esq	Tracing of reconnaissance of Absecom inlet, N. J. in 1854.
17	Hons. A. H. Stephens and J. L. Seward	Tracing of reconnaissance of Brunswick harbor, Ga.
19	Capt. A. A. Humphreys, Topographical Engin'rs	Tracing of sketch of Atchafalaya bay, La.
20	General Land Office	Tracing of Anacapa and east end of Santa Cruz islands, Cal.
22	Hon. W. W. Boyce	Tracing of Port Royal entrance, S. C.
25	H. F. Walling, Esq	Tracings of topography of portions of coast of Massachusetts.
April 2	G. W. Blunt, Esq	Tracing of hydrography from Mobjack bay to Cape Henry, Chese eake bay.

APPENDIX No. 5—Continued.

Date.		To whom communicated.	Information communicated.
1856.			
April	2	Charles Copley, Esq	Tracing of hydrography of East river, from Randall's island to Throg's neck.
	7	War Department	Tracing from sketch of mouth of Miami river, Fla.
	9	R. H. Long, Esq	Tracing of hydrographic survey of St. Andrew's bay, Fla.
	11	M. P. Muller, Esq	Tracing of triangulation and topography of Cedar keys, Fla.
	12	Hon. D. L. Yulee	Copy of chart of Cumberland sound and Amelia bar, Fla.
	18	Hon. Mitchell King	Tracing of hydrography of Savannah river from, and including, Hutchinson's island to head of Onslow island, Ga.
	18	D. B. Bryant, Esq	Latitude, longitude, and description of geodetic station, Sebattis Mount, Me.
	21	John H. Scranton, Esq	Tracing of hydrographic survey of Olympia harbor, Puget's Sound, Washington Territory.
	21	------do	Tracing of hydrographic survey of Steilacoom harbor, Puget's Sound, Washington Territory.
	21	Hon. J. Morrison Harris	Tracing of Patapsco river from Baltimore to middle of Chesapeake bay.
	24	Light-house Board	Tracing of Swash channel, New York bay.
	25	Charles Copley, Esq	Tracing of additional soundings in Nantucket sound.
	29	C. W. Moesta, Esq	Moon culminations observed on certain days of 1852, 1853, 1854, 1855, and 1856.
May	6	Professor Joseph Henry	Latitude, longitude, and elevation above the sea, of Coast Survey station at Mount Holly, N. J.
	6	James Miller, Esq	Latitude and longitude of Shepard's Point and Arundel signals, near Beaufort, N. C.
	9	Gen. T. Tilghman	Tracing of part of Pocomoke sound, Chesapeake bay.
	19	Engineer Bureau	Tracing of part of Hell Gate channel, near Blackwell's Point, New York.
	24	Gouverneur Morris, Esq	Tracing of soundings of East river, near Morrisiana, New York.
	24	Commissioners on New York harbor	Copy of original topographic and hydrographic sheets of New York bay and harbor.
	26	United States Fishery Commissioner	Tracing of topography of Saugus river and vicinity, Mass.
June	2	---------do---------do	Tracing of topography of Weir river and vicinity, Mass.
	2	W. B. Hill, Esq	Tracing of Delaware river, from mouth of Schuylkill to navy yard, Philadelphia.
	6	United States Fishery Commissioner	Tracing of topography of Parker's river and vicinity, Mass.
	6	---------do---------do	Tracing of topography of Back river, Monument river, Wareham, and Weneantic rivers, Mass.
	6	---------do---------do	Tracing of topography of Nastetucket river and vicinity, Mass.
	6	---------do---------do	Tracing of topography of Acoaksett river and vicinity, Mass.
	9	---------do---------do	Tracing of southern extremity of Cape Cod, Mass.
	9	---------do---------do	Tracing of topography of Osterville river and harbor, Cotuit river, and Peponset bay, Mass.
	10	A. S. Baldwin, Esq	Tracing of St. John's river, from entrance to Jacksonville, Florida.
	14	Prof. W. C. Bond	Determination of longitude of Bangor, Maine.
	17	Baron Von Muller	Certain magnetic constants and examples for determining magnetic elements.
	18	Edward O. Boyle, Esq	Tracing of Coenties' reef, New York harbor.
	20	E. W. Seabrook, Esq	Tracing of sketch of Edisto island, S. C.
July	3	A. Hawley, Esq	Tracing of part of Upper Galveston bay, Texas.
	3	J. B. Mills, Esq	Data to establish a meridian from certain Coast Survey stations opposite Peekskill, on the Hudson river.
	8	A. Hawley, Esq	Tracing of entrance of Trinity river, Galveston bay, Texas.
	10	Lieut. W. H. Stevens, Corps of Engineers	Tracing of topography of Galveston island, Texas.
	10	G. W. Blunt, Esq	Tracing of coast between Salem and Cape Ann, Mass., and soundings in Vineyard sound.
	15	Hon. W. Cost Johnson	Tracing of Point Lookout and vicinity, Md.
	24	Light-house Board	Tracing of entrance of Rappahannock river, Chesapeake bay.
	24	-------do	Tracing of hydrography near Smith's Point, Chesapeake bay.
	30	Hon. D. L. Yulee	Tracing of St. Mary's bar and Fernandina harbor, Fla.
Aug.	7	S. D. Backus, Esq	Tracing of the topography of Byram river, Conn.
	11	G. W. Blunt, Esq	Tracing of Commander Sands' soundings, from Savannah, Ga., to the Belize, in 1856.
	15	H. Wilson Harris, Esq	Tracing from reduction of Chesapeake bay, north of Patapsco river, Md.
	16	Hon. J. B. Ricaud	Tracing of Bush river, Md.
Sept.	15	Cortland Parker, Esq	Copy of a report on the currents in Passaic river, N. J.
	25	Engineer Bureau	Tracing of St. John's river, Fla.

APPENDIX No. 5—Continued.

Date.		To whom communicated.	Information communicated.
1856.			
Oct.	10	G. W. Blunt, Esq	Tracing of hydrographic survey of North Edisto bar, S. C.
	10	......do	Tracing of hydrographic survey of Port Royal entrance, S. C.
	10	Sir Wm. E. Logan	Projection from 39° to 54° north latitude, and from 54° to 98° west longitude from Greenwich.
	14	J. P. Jackson, Esq	Tracing from hydrographic survey of Newark bay, N. J.
	16	H. F. Walling, Esq	Tracings of topographic surveys on the coast of Massachusetts, from Plymouth to Buzzard's bay, including Martha's Vineyard, Nantucket island, and No-Man's-Land.
	18	Land Office	Topography of Mud, Snipe, and Saddle Bunch keys, Fla.
	18	......do	Topography of Johnson and Sawyer keys, Fla.
	18	......do	Topography of Sugarloaf, Cudjoe, Summerland, and Loggerhead keys, Fla.

APPENDIX No. 6.

List of capes, headlands, islands, harbors, and anchorages, on the western coast of the United States, of which either preliminary, topographical, or complete surveys have been made, or maps, charts, or sketches issued to date of report of 1856.

Names, in geographical order.	Character of survey.	Published.
CAPES AND HEADLANDS.		
Point Loma	Topographical survey	Sketch
Point Pedro	do	do
Point Fermin	do	do
Buenaventura mission	do	
Point Conception	do	Sketch
Point Piños	do	do
Point Año Nuevo	do	do
Point Lobos	do	do
Point Bonita	do	do
Ballenas bluff	do	
Point Reyes	do	Sketch
Point Adams	do	do
Cape Disappointment	do	do
Cape Flattery	do	do
ISLANDS.		
Los Coronados islands	Topographical survey	Sketch
Anacapa island	do	do
Santa Cruz island	do	do
South Farallon island	Reconnaissance	do
Alcatraz island	Topographical survey	do
Yerba Buena island	do	do
Angel island	do	do
Mare island	do	
Sand island	do	Sketch
Smith's island	Preliminary survey	do
Cypress island	Topographical survey	
HARBORS AND ANCHORAGES.		
San Diego harbor	Preliminary survey	Sketch
San Clemente harbor	do	do
Catalina harbor	do	do
San Pedro harbor	Topographical survey	do
Cuyler's harbor, island of San Miguel	Preliminary survey	do
Prisoners' harbor, Santa Cruz island	do	do
Smugglers' cove, Santa Cruz island	Topographical survey	
Santa Barbara anchorage	do	Sketch

APPENDIX No. 6—Continued.

Names, in geographical order.	Character of survey.	Published.
HARBORS AND ANCHORAGES—Continued.		
Coxo harbor	Preliminary survey	Sketch
San Luis Obispo harbor	do	do
San Simeon harbor	do	do
Monterey harbor	Topographical survey	do
Sauquel cove	do	
Santa Cruz harbor	do	Sketch
Point Año Nuevo harbor	do	do
San Francisco harbor	Complete survey	do
Mendocino City harbor	Preliminary survey	do
Shelter cove	do	do
Crescent City harbor	do	do
Port Orford, or Ewing harbor	do	do
Grenville harbor	do	do
Neé-ah harbor	do	do
False Dungeness harbor	do	do
New Dungeness harbor	Topographical survey	
Port Townshend	do	Sketch
Port Ludlow	do	
Mats-Mats, or Boat harbor	do	
Port Gamble	Preliminary survey	
Blakely harbor	do	
Steilacoom harbor	do	
Olympia harbor	do	
BAYS.		
San Diego bay	Topographical survey	Sketch
False bay	do	
Monterey bay	do	Sketch
San Francisco bay	do	do
San Pablo bay	do	
Ballenas bay	do	
Sir Francis Drake's bay	Preliminary survey	Sketch
Tomales bay	Topographical survey	
Humboldt bay	Preliminary survey	Sketch
Trinidad bay	do	do
Shoalwater bay	do	do
Duwamish bay	do	do
Strawberry bay	Topographical survey	
Bellingham bay	Preliminary survey	Sketch
REEFS AND BANKS OR SHOALS.		
Cortez bank	Preliminary survey	Sketch
Duxbury reef	do	do
STRAITS AND ENTRANCES.		
San Diego entrance	Topographical survey	Sketch
San Francisco entrance	Complete survey	do
Mare Island straits	Topographical survey	do
Umpquah River entrance	Preliminary survey	do
Columbia River entrance	Complete survey	Preliminary chart
Admiralty inlet	Preliminary survey	Sketch
Canal de Haro and straits of Rosario	do	do
RIVERS.		
Santa Clara river	Topographical survey	
Salinas river	do	
Pajaro river	do	
CITIES.		
City of Monterey	Topographical survey	Sketch
City of San Francisco	do	Map
City of Benicia	do	

APPENDIX No. 7.

Results of the Coast Survey at different periods, from 1844 *to* 1856.

	Previous to 1844.	From 1844 to 1855.	For 1855.	Total from beginning of survey.
Reconnaissance :				
Area, in square miles	9,642	34,757	1,487	45,886
Parties, number of	----------	----------	7	----------
Base lines :				
Primary, number of	1	7[a]	2	9
Secondary, number of	2	24	8	35
Length of, in miles	19½	90¾	24¼	134½
Triangulation :				
Area, in square miles	9,076	24,787	2,729	36,592
Extent of coast-line, in miles	310	1,667	375	2,352
Extent of shore-line, in miles	3,215	9,792	1,270	14,277
Horizontal angle stations, number of	750	1,811	410	2,971
Points determined, number of	1,183	3,188	584	4,955
Vertical angle stations, number of	15	181	6	202
Heights determined, number of	44	446	6	496
Astronomical stations :				
Azimuth, number of	9	52	4	65
Latitude, number of	9	87	4	100
Longitude, number of	1	70	1	72
Longitude, (permanent,) number of	----------	----------	3	----------
Magnetic stations, number of	----------	146	8	154
Triangulation parties, number of	----------	----------	20	----------
Astronomical parties, number of	----------	----------	6	----------
Magnetic parties, number of	----------	----------	5	----------
Topography :				
Area, in square miles	6,222	5,642	532	12,396
Length of shore-line, in miles	6,100	11,415	1,356	18,871
Topographical parties, number of	----------	----------	14	----------
Hydrography :				
Area, in square miles	9,623	----------	----------	----------
Parties, number of	----------	----------	11	----------
Soundings, number of	808,147	2,608,215	526,875	3,943,237
Soundings in Gulf stream for temperature	----------	1,715	137	1,852
Fathoms of line used in same	----------	176,757	4,268	181,025
Tidal stations, number of	108	401	104	613
Tidal parties, number of	----------	----------	3	----------
Current parties, number of	----------	----------	1	----------
Current stations, number of	----------	444	84	528
Specimens of bottom, number of	----------	4,736	253	4,989
Topographical maps, (original,) number of	166	297	77	540
Hydrographic maps, (original,) number of	127	303	60	490
Reductions and other maps	326	834	168	1,328
Total number of manuscript maps	619	1,434	305	2,358
Records of triangulation, (original,) number of volumes	97	276	79	452
Records, astronomical, (original,) number of volumes	17	314	35	366
Records, magnetic, (original,) number of volumes	4	59	33	96
Duplicates of the above, number of volumes	27	483	139	649
Computations, number of volumes	78	422	109	609
Hydrographic books, soundings and angles, (original,) number of volumes	188	1,445	332	1,965
Sounding and angle observations, (duplicates,) number of volumes	28	119	26	173
Hydrographic books, tidal and current, (original,) number of volumes	127	831	196	1,154
Tidal and current observations, (duplicates.) number of volumes	----------	924	87	1,011
Hydrographic books, tidal reductions, number of volumes	----------	333	60	393
Total records, number of volumes	566	5,206	1,096	6,868
Library, number of volumes	1,327	2,272	250	3,849
Engraved plates of maps, number of	5	47	8	60
Engraved plates electrotyped, number of	----------	202	50	252
Published maps, number of	----------	56	1	57
Printed sheets of maps distributed, number of	----------	34,537	5,392	39,929
Printed sheets of maps, with sale agents, number of	----------	42,550	2,577	45,127
Total number of printed sheets	----------	155,193	34,927	190,120
Instruments, cost of	31,872	56,705	3,958	92,535

[a] One of these was rated as secondary.

APPENDIX No. 8.

General list of Coast Survey discoveries and developments to 1855, *inclusive.*

1. Determination of the dimensions of Alden's Rock, near Cape Elizabeth, Maine—1854.
2. Determination of rocks off Marblehead and Nahant—1855.
3. A rock (not on any chart) in the inner harbor of Gloucester, Mass.—discovered 1853.
4. A bank, ninety miles eastward of Boston, with about thirty-six fathoms of water—probably a knoll connected with Cashe's ledge, but with deep water between it and the ledge—1853.
5. Boston harbor: Broad Sound channel thoroughly surveyed, and marks recommended—1848.
6. Several rocks in the fair channel-way in Boston harbor entrance—1854.
7. A bank, (Stellwagen's Bank,) with ten and a half to fourteen and a half fathoms of water on it, at the entrance to Massachusetts bay, and serving as an important mark for approaching Boston and other harbors—1854.
8. Extension of Stellwagen's Bank to the southward and eastward some sixteen or seventeen square miles, enclosed by the twenty-fathom curve—1855.
9. A dangerous sunken ledge (Davis' ledge) to the eastward and in the neighborhood of Minot's ledge—1854.
10. Probable connection of George's Bank and the deep-sea banks north and east of Nantucket—1855.
11. Nantucket shoals: Davis' New South shoals, six miles south of the old Nantucket South shoals, in the track of all vessels going between New York and Europe, or running along the coast from the Eastern to the Southern States or South America—discovered in 1846.
12. Two new shoals north and east of Nantucket—discovered in 1847.
13. Six new shoals near Nantucket, the outermost fourteen and a half miles from land, and with only ten feet water—discovered in 1848.
14. McBlair's shoals, off Nantucket—discovered in 1849.
15. The tidal currents of Nantucket shoals and the approaches—1854.
16. Davis' Bank, Nantucket shoals—discovered in 1848, and survey finished in 1851.
17. Fishing Rip, a large shoal extending north and south about ten miles to the eastward of Davis' Bank, and thirty miles from Nantucket, with four and a half fathoms—surveyed in 1852.
18. A ridge connecting Davis' New South shoal and Davis' Bank—found in 1853.
19. A small bank or knoll, with but five fathoms on it, about five miles east of Great Rip, with twelve fathoms between it and Davis' Bank and Fishing Rip, the water gradually deepening outside of it to the northward and eastward, beyond the limits of the series of shoals.
20. Discovery of Edwards' shoal, one mile and seven-eighths southward of Nantucket lightboat—1855.
21. Examination of the interference tides of Nantucket and Martha's Vineyard sounds—1855.
22. Contraction of the inlet at the north end of Monomoy island, and opening of new entrance to Chatham harbor—1853.
23. Muskeget channel—surveyed by Lieutenant C. H. Davis in 1848, and Lieutenant C. H. McBlair in 1850.
24. Numerous rocks in Martha's Vineyard sound, Long Island sound, and the various bays and harbors connected with them.
25. The tidal currents of Long Island sound, 1854.
26. The currents of the great bay between Massachusetts, Rhode Island, Connecticut, New York, and New Jersey—1855.
27. Gedney's channel into New York bay, having two feet more water than the old channels.

Had the true depth of this channel been known in 1778, (then probably existing, as seen by comparing old and new charts,) the French fleet under Count D'Estaing would have passed into the bay, and taken the assembled British vessels.

28. The changes in New York harbor, near New York city, between 1845 and 1856.

29. Increase of depth in Buttermilk channel, ascertained and made known in 1848 by survey of Lieut. D. D. Porter, U. S. N.

30. Changes in New York bay and harbor—1855.

31. Shoal in the main ship-channel of New York harbor—1855.

32. Sandy Hook: Its remarkable increase traced from the surveys of the topographical engineers and others, and by several successive special surveys made between 1844 and 1856.

33. Delaware bay: Blake's channel at the entrance, discovered in 1844—open when the eastern channel is closed by the ice. This discovery has served to develop strikingly the resources of that portion of Delaware.

34. Blunt's channel in Delaware bay.

35. Changes in the Delaware near the Pea Patch.

36. The true extent and position of the dangerous shoals near Chincoteague Inlet, Va.—1852.

37. Metompkin Inlet, Va., shoaling from eleven to eight feet in the channel during 1852.

38. Two channels into Wachapreague Inlet, Va.—one from the northward and the other from the eastward—both with seven feet water at low tide—1852.

39. A shoal half a mile in extent, not put down on any chart, 5½ miles east from the north end of Paramore's island, Va.: it has but four fathoms water on it, and nine fathoms around it—1852.

40. Great Machipungo Inlet, Va.; found to have a fine wide channel, with eleven feet water on the bar at low ebb, and fourteen at high tide; good anchorage inside in from two to eight fathoms; the best harbor between the Chesapeake and Delaware entrances—1852.

41. Two shoals near the entrance to the Chesapeake—one 4¾ nautical miles S. E. by E. from Smith's Island light-house, with seventeen feet water upon it; the other E. by S. nearly, 7¾ miles from the same light, with nineteen and a half feet upon it—1853.

42. Only three feet water upon the "Inner Middle," the shoal part of the Middle Ground west of the "North Channel," at the Chesapeake entrance—1852.

43. A twenty-five fathom hole 2½ miles west-southwest from Tazewell triangulation point, eastern shore of the Chesapeake; all other charts give not more than sixteen fathoms in this vicinity.

44. A shoal at the mouth of the Great and Little Choptank, in Chesapeake bay—1848.

45. The bars in Rappahannock river—1855.

46. The general permanence of the Bodkin channel, and shoals in its vicinity, at the entrance of the Patapsco river—between 1844 and 1854.

47. A shoal (New Point shoal) in Chesapeake bay, with sixteen feet water on it, southeast from New Point Comfort light-house, off Mobjack bay—1854.

48. Re-examination of York Spit, Chesapeake bay, and least water determined (nine feet)—1855.

49. A reconnaissance of the Wimble shoals, near Nag's Head, coast of North Carolina—1854.

50. Sub-marine range of hills beyond the Gulf Stream, tracked from Cape Florida to Cape Lookout—1855.

51. Deeper water found on Diamond shoal, and a dangerous nine-feet shoal off Cape Hatteras—1850.

52. A new channel, with fourteen feet water, into Hatteras Inlet, formed during the year 1852, which is better and straighter than the old channel.

53. The well ascertained influence of prevailing winds in the movement of the bars at Cape Fear and New Inlet entrances, and the gradual shoaling of the main bar; the latter fact being of great importance to the extensive commerce seeking this harbor—1853.

54. Changes in the main Western and New Inlet channels into Cape Fear—1855.

55. Frying-Pan shoals, off Cape Fear, N. C. A channel of 2½ fathoms, upwards of a mile wide, distant 11 nautical miles from Bald Head light-house, across the Frying-Pan shoals. A channel extending from 3 to 4 miles from the point of Cape Fear to 8 or 8½ miles from it, with sufficient water at low tide to allow vessels drawing 9 or 10 feet water to cross safely. A channel at the distance of 14 nautical miles from Bald Head light-house, one mile wide, with 3½ to 7 fathoms water in it. The Frying-Pan shoals extend 20 nautical miles from Bald Head light-house, and 16, 17, and 18 feet water is found 17 and 18 nautical miles out from the light—1851.

56. Shoaling of Cape Fear river bar thoroughly examined for purposes of improvement—1852.

57. The general permanence in depth on the bar of Beaufort, N. C., with the change of position of the channel—1854.

58. Changes at the entrance of Winyah bay and Georgetown harbor, and the washing away of Light-house Point, at the same entrance—1853.

59. Maffitt's new channel, Charleston harbor, with the same depth of water as the ship channel—1850.

60. The changes in Maffitt's channel, Charleston harbor, S. C., from 1852 to 1856.

61. Changes in the main ship channel, Charleston harbor—1855.

62. Changes in the channels at the entrance of Charleston harbor—1852.

63. The remarkable discovery of continuous deep-sea soundings off Charleston, and of soundings in the depth of between four and five hundred fathoms beyond the Gulf Stream—1853.

64. The discovery of cold water at the bottom of the ocean below the Gulf Stream, along the coasts of North and South Carolina, Georgia, and Florida—1853.

65. The discovery of the cold wall, alternate warm and cold bands, and various other features of the Gulf Stream, especially such as concern its surface and deep-sea temperatures, and its distribution relative to the shore and bottom of the ocean.

66. Various facts relative to the distribution of minute shells on the ocean bottom, of probable use to navigators for recognizing their positions.

67. Examination of Doboy, St. Simon's, and Cumberland entrances—1855.

68. Hetzel shoal, off Cape Cañaveral, Florida—1850.

69. Temperature of 34° beneath the Gulf Stream, thirty-five miles east of Cape Florida, at a depth of three hundred and seventy fathoms—1855.

70. A harbor of refuge (Turtle harbor) to the northward and westward of Carysfort light-house, Florida reef, with a depth of water of twenty-six feet at the entrance—1854.

71. A new passage, with three fathoms water, across Florida reef to Legaré harbor, under Triumph reef (latitude 25° 30′ N., longitude 80° 03′ W.,) which, if properly buoyed, will be valuable as a harbor of refuge.

72. A safe rule for crossing the Florida reef near Indian key—1854.

73. A new channel into Key West harbor—1850.

74. Co-tidal lines for the Atlantic coast of the United States—1854.

75. Isaac shoal, near Rebecca shoal, Florida reef; not laid down on any chart—1852.

76. Channel No. 4, a northwest entrance into Cedar Keys bay—1852.

77. Mobile Bay entrance bar; in 1822 only seventeen feet at low water could be carried over it; in 1841 it had nineteen; and in 1847 twenty feet and three-quarters, as shown by successive surveys—1847.

78. The diminution, almost closing, of the passage between Dauphine and Pelican islands, at the entrance of Mobile bay—1853.

79. Horn Island channel, Mississippi sound.

80. The removal of the East Spit of Petit Bois island, in the hurricane of 1852, opening a

new communication between the Gulf and Mississippi sound, and the rendering of Horn Island Pass more easy of access by the removal of knolls—1853.

81. The accurate determination of Ship shoal, off the coast of Louisiana, in connection with the site for a light-house—1853.

82. An increase of depth of water on the bar at Pass Fourchon, Louisiana—1854.

83. Deep-sea soundings in the Gulf of Mexico—1855-'56.

84. Tidal phenomena of the Gulf—1855.

85. The changes at Aransas Pass, Texas, as bearing on the question of a light-house site—1853.

86. The determination of the position, and soundings on Cortez Bank, off the coast of California—1853.

87. Determination of the position of Cortez Rock—1855.

88. A shoal inside of Ballast Point, San Diego bay, with only twelve and a half feet water; not laid down on any chart—1852.

89. Determination of Uncle Sam Rock—1855.

90. Red sand, marking the inner entrance to the Golden Gate—1855.

91. Channel sounded out between Yerba Buena and the Contra Costa, San Francisco bay—1855.

92. Changes in the channel entrances of Humboldt bay or harbor, California—1852 and 1853.

93. South channel, Columbia river, surveyed and made available to commerce—1851. Changes of channels, their southward tendency, and a new three-fathom channel from Cape Disappointment, due west, to open water, Columbia entrance—1852. Further changes—1853.

94. The depth of water on the bars at the entrance of Rogue river and Umpquah river, Oregon—1853.

95. A shoal at the entrance to the Straits of Rosario, Washington Territory, giving good holding ground in thirty-three feet—1854.

96. Boulder reef, northwest of Sinclair island, Rosario strait, partly bare at unusually low tides, and surrounded by kelp—1854.

97. Belle Rock, in the middle of Rosario strait, Washington Territory, visible only at extreme low tides—1854.

98. Entrance Rock, at the entrance of Rosario strait—1854.

99. Unit Rock, in the Canal de Haro, Washington Territory—1854.

100. A five-fathom shoal in the Strait of Juan de Fuca, between Canal de Haro and Rosario strait—1854.

101. The non-existence of two islands at the northern entrance of Canal de Haro, laid down on charts—1854.

102. The non-existence of San Juan island, usually laid among the Santa Barbara group—1854.

103. Tides of San Diego, San Francisco, and Astoria—1854.

104. Co-tidal lines of the Pacific coast—1855.

105. Various surveys and charts of small harbors on the Pacific, and a continuous reconnaissance of the entire Western Coast and islands adjacent, a great part of which was imperfectly known.

Additional list for 1856.

1. Determination of the position of a sunken rock, on which the steamer Daniel Webster struck, in Casco bay, on the evening of the 13th of October.

2. Development of a reef extending between Minot's and Scituate light.

3. A sunken rock, with only six feet on it at low water, off Webster's flag-staff, Massachusetts bay.

4. A dangerous rock, near Saquish Head, entrance to Plymouth harbor.

5. Three rocks determined in position, partly bare at low water, off Manomet Point, Massachusetts bay.

6. Determination of a very dangerous rock off Indian hill, and four miles southward of Manomet Point, Massachusetts bay, with as little as six feet water on it.

7. Non-existence determined of "Clark's Bank" and "Crab Ledge," laid down on certain charts as distinct from an immense shoal ground off Cape Cod peninsula.

8. Discovery of two shoal spots, with twelve and thirteen feet water, eastward from Great and Little Round shoals, Nantucket sound.

9. Determination of two shoal spots near the northern extremity of Davis' Bank, with fourteen and eighteen feet water.

10. Further development of Edwards' shoal, three fourths of a mile from the Southern Cross Rip, Nantucket sound.

11. Of shoal sand ridges, discovered northward of Great Point light, Nantucket sound.

12. Important changes in geographical feature at the southeastern end of Martha's Vineyard, Muskeget channel.

13. Determination of changes occurring in New York harbor.

14. Investigation of the cause of changes at Sandy Hook.

15. The tides of Hudson river.

16. Development of the changes affecting the entrance to North Edisto river, S. C.

17. Discovery of a new channel between Martin's Industry (shoal) and the southeast breakers, Port Royal entrance, S. C.

18. Directions for entering the harbor from Crystal River offing, western coast of Florida peninsula.

19. Co-tidal lines of the Gulf of Mexico.

20. On the effect of wind in disturbing the tides of the Gulf of Mexico.

21. Development of a bar at the entrance to San Diego bay, California.

22. Complete hydrographic survey and determination of a point of rock on Cortez shoal.

23. Investigation of the currents of Santa Barbara channel.

24. Further development of the extent of Commission Rock, San Pablo bay.

APPENDIX No. 9.

Letter to the Secretary of the Treasury, reporting determination of the position of a rock upon which the steamer Daniel Webster struck in Casco bay.

New York, *October* 24, 1856.

Sir: I have the honor to append, for the information of the Department and the Light-house Board, the following extracts from the report of Lieut. Comg. S. D. Trenchard, U. S. N., assistant in the Coast Survey, on determining, by my direction, the position of a rock in Casco Bay, on which the steamer Daniel Webster struck, on a recent passage from Bangor to Portland.

"The rock bears N. by E.½E. by compass, from the centre of *Half-way Rock*, and lies about a sixth of a mile from it. The least depth upon the rock is from ten to fifteen feet at mean low water, and at extreme low tides, less than eight feet.

"Its extent does not exceed five yards square. The soundings between it and *Half-way Rock* deepen suddenly to six and seven fathoms, (at mean low water,) but to the northward more gradually to nine and ten fathoms.

"This rock lies directly in the track of steamers passing to and from the eastward of Portland, and I would recommend that a buoy be placed upon it.

"The steamer Daniel Webster struck upon the rock at 4.30 p. m., on the 13th instant, the weather being cloudy and rainy. The tide was remarkably low on that day. Captain Blanchard states the draught of the steamer then as seven feet.

"I am greatly indebted to Captain Waldron, of the United States revenue marine, for his kind efforts in aiding me to find the rock referred to."

I would respectfully request that a copy of this communication may be sent to the Light-house Board.

Very respectfully, yours,

A. D. BACHE,
Superintendent U. S. Coast Survey.

Hon. JAMES GUTHRIE, *Secretary of the Treasury.*

APPENDIX No. 10.

Letter to the Secretary of the Treasury, transmitting extracts from a report of Commander H. S. Stellwagen, U. S. N., assistant in the Coast Survey, on developments of dangers to navigation between Point Allerton and Plymouth harbor, coast of Massachusetts.

MOUNT DESERT STATION,
Near Ellsworth, Maine, September 26, 1856.

SIR: I have the honor to communicate, for the general benefit of the navigation of Massachusetts bay, between Point Allerton and Plymouth harbor, and for the information of the Light-house Board, the following extracts from a report made by Commander H. S. Stellwagen, U. S. N., assistant in the Coast Survey, on the progress of hydrographic work executed within the season in that vicinity, under his command:

"Several rocks were found extending in a reef from Scituate light towards Minot's light-boat, the outer one of which is the ledge reported by me in 1853, and subsequently by Commander Davis. I have located it correctly by angles, for the first time, and carefully triangulated the peaks, some nine in all, which make up the reef. The positions are shown on the accompanying sketch, within a red line, from which the natural connection of the rocks can be readily inferred. A good depth of water occurs between the peaks, yet by reason of their proximity to each other the reef which they form is very dangerous. These rocks should be marked by buoys.

"The tracing shows also the position of a sunken rock, with six or seven fathoms water, off Webster's flag-staff, lying three-quarters of a mile outside of a rock on which a buoy is placed, likely to lead vessels on the outer rock.

"A rock near Saquish Head, entrance to Plymouth harbor, is dangerous to vessels beating in. It is quite sharp and not easy to detect. The position is marked on the enclosed tracing.

"In addition to those mentioned, I have to report the determination of three rocks, partly bare at low water, off Holmes (Manomet) Point. On these a British vessel (the Mary Ann) was lost some years ago."

Commander Stellwagen has also determined and reported the position of a detached and very dangerous rock, lying off Indian Hill. This was found about four miles to the southward of Manomet Point, and has as little as six feet water on it. The existence of the rock seems to have been very little known.

I would respectfully request authority to publish this communication in the usual form, and that a copy of the same be transmitted from the Department to the Light-house Board.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE, *Secretary of the Treasury.*

APPENDIX No. 11.

Letter to the Secretary of the Treasury, communicating particulars of developments recently made by Commander H. S. Stellwagen, U. S. N., assistant in the Coast Survey, in the vicinity of Nantucket shoals.

ALBANY, *August* 29, 1856.

SIR: I have the honor to communicate the following developments reported to me by Commander H. S. Stellwagen, U. S. N., assistant in the Coast Survey, under date of the 19th instant. In the progress of his hydrographic work to the eastward of the peninsula of Cape Cod, his general examination was carried also southward as far as the latitude of Sankaty light. The immediate results reported are the discovery of a new shoal in latitude 41° 27′ N., longitude 69° 51′ W., lying in the middle of the ship channel between Great Round shoal and McBlair's shoal. The least water found was twelve feet, and it is intimated by Commander Stellwagen that a minute survey may possibly develop the existence of spots having a less depth.

A shoal was also found eastward from the northern extremity of Little Round shoal with as little as thirteen feet water. This shoal lies in latitude 41° 31′ 15″ N., and longitude 69° 52′ 05″ W.

The existence of a very narrow ridge, with only fourteen feet water, was detected at the northern extremity of Davis' Bank, Sankaty light bearing West ½ South, distant fifteen and a half nautical miles.

Two miles due north of the last mentioned shoal, a ridge was found stretching about a mile in a N.W. and S.E. direction, having within a small space upon it only eighteen feet water.

The season's operations of Commander Stellwagen, yet in progress eastward of the Cape Cod peninsula, have determined the non-existence of Crab Ledge and Clark's Bank; but a large extent of shoal water, with soundings in nine and fifteen fathoms, was found S.W. and W.S.W. from George's shoal, for which no soundings have yet been indicated on published charts.

The recommendations of Commander Stellwagen, for placing buoys upon the shoal spot at the northern extremity of Davis' Bank and on that immediately north of it, have been communicated to the Light-house Board.

I would respectfully request authority to publish the information herein contained, in the usual form, for the general benefit of navigators.

Very respectfully, yours,

A. D. BACHE,
Superintendent U. S. Coast Survey.

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

APPENDIX No. 12.

Letter to the Secretary of the Treasury, communicating extracts from a report of Lieut. Comg. C. R. P. Rodgers, U. S. N., assistant in the Coast Survey, upon the development of Edwards' shoal, and the existence of shoal sand ridges northward of Great Point light, Nantucket sound.

COAST SURVEY OFFICE, *December* 8, 1856.

SIR: I have the honor to communicate, as in part the result of a close hydrographic survey of Nantucket sound completed within the present season, the further development of Edwards' shoal, by Lieut. Comg. C. R. P. Rodgers, U. S. N., assistant in the Coast Survey, and the discovery of shoal ridges of sand lying northward of Great Point light. The existence of

Edwards' shoal was communicated to the Department in my letter of November 6, 1855. The following extracts from the report addressed to me by Lieut. Comg. Rodgers contain the result of his subsequent minute examination, and a description of the character of the sand ridges referred to:

"At the end of last season I had the honor to report the discovery and partial examination of a shoal south of the Cross Rips, in Nantucket sound, which, with your sanction, has been called Edwards' shoal. This was carefully surveyed in the operations of my party during the season just ended. It lies in the channel-way south of the Cross Rips, surrounded by deep water, and its crest is a narrow ridge, more than half a mile in length, with only ten and twelve feet water upon it. It may consequently be considered worthy of special attention, and should at once be carefully buoyed.

"From the eastern side of this ridge, which rises like a wall in the sea, the water deepens abruptly to five fathoms, and at its southern end, within the space of a few yards, from eleven feet to eight fathoms. On the western side, the ridge falls off more gradually, and from its centre a spur of shoal makes out to the westward for more than a quarter of a mile, with sixteen and eighteen feet water upon it.

"The shoal is composed of hard sand. Its northern edge is distant from the Nantucket light-boat a mile and seven-eighths, (nautical,) and from the southern Cross Rip about three quarters of a mile. In the channel between it and the Cross Rips we found from six to ten fathoms water.

"It is remarkable that a shoal like this, so constantly passed by vessels beating through the southern channel of Nantucket sound, should have been so long unknown, and particularly that it should have escaped the notice of pilots.

"Its discovery forcibly illustrates the value of the comprehensive methods employed in the Coast Survey, and the practical utility of making the hills and valleys in the sea as well known as those on the shore.

"I beg leave to report, also, that the developments of our survey during the season exhibit sand ridges a little more than two miles to the northward of Great Point light, bearing from it N. 1° 30′ W. to N. 22° 30′ W., and having in some places on their crests as little as nineteen feet water. They lie parallel to each other in a general direction about N.N.W. and S.S.E., are short and very narrow, and have five and six fathoms of water around and between them."

I would respectfully request authority to publish this communication in the usual form, and also that a copy may be transmitted to the Light-house Board for information, as connected with the recommendation of Lieut. Comg. Rodgers for placing a buoy on Edwards' shoal.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. James Guthrie, *Secretary of the Treasury.*

APPENDIX No. 13.

Letter of Assistant Henry L. Whiting, with particulars in detail of changes in shore-line, noticed in a re-examination of the topography of Martha's Vineyard, bordering Muskeget channel.

Richmond, Staten Island, N. Y., *June* 14, 1856.

Dear Sir: The occupations and arrangements incident to my commencing operations here prevented me from making my report on the resurvey and examinations for Muskeget channel, Mass., which I now submit.

The work was executed at different times between the receipt of your instructions and the 8th of May, when I completed the survey. These intervals of work were in consequence of the very changeable and unsettled weather which prevailed at that time. With regard to the changes in the shores and beaches at the southeast part of the Vineyard, they have been quite considerable, and seem to indicate a gradual encroachment of the sea upon the south shores of the island. The beach has beaten, in places, directly in upon the island, together with a gradual moving of the points, inlets, &c., *eastward*, being the same action which I have observed at all points of our northern coast of similar character, as at Sandy Hook, Cape Cod, &c. There was a new opening broken through the long beach which formerly stretched across the whole of Catamy bay, (the water south of Edgartown and between the main island and Chappaquiddick.) This opening is now about a third of a mile wide, and the beach on either side of it has been driven in towards the bay about a thousand feet. This is now the main opening, and the tide is so strong through it as to materially affect the harbor, and make it difficult for vessels in light winds to stem it in coming in from Cape Poge. The east opening, which was formerly the only one, has worked still further eastward, and become much narrower than it was; the outside beach has made eastward, extending past the south point of Chappaquiddick, (Wasque Point,) which has been washed away nearly a thousand feet. This action of the sea indicates a gradual wearing away of the southern shore of the island; and I think, in this particular locality, the beach may eventually be entirely swept away, or washed in upon either shore, leaving the bay between the Vineyard and Chappaquiddick an open chop. In this case the character and capacity of Edgartown harbor will be greatly changed; whether it will tend to deepen the eastern channel and improve it, or carry the sand, &c., through and deposit it in shoals towards Cape Poge, is a question for time to develop.

The greater quantity and velocity of the current sweeping through the harbor will have a strong effect upon the shore and wharves of Edgartown. In fact, its influence is already felt.

A heavy gale, with heavy and continued breakers, may throw up another beach, and close this new south opening; but I think the indications point to its being finally swept away.

At Muskeget I found very considerable and marked changes, although the action and alteration of the shore and beaches are not so uniform as on the Vineyard. The general tendency seems to be a making northward, and driving of the outer beaches upon the islands and sandbars lying inside or north of them. The beach south of Tuckernuck island has been driven in towards the island nearly its full width, and the channel between it and Tuckernuck, which was formerly quite a passage, is nearly one-half filled up, and much shoaler than it was. This is the case at the south end of Muskeget; and off Gravelly island the beach was driven entirely in upon it. A beach of nearly a mile in length, which extended past both Gravelly island and the south point of Muskeget, and was about a quarter of a mile outside and south of them, has entirely disappeared. The southwest part of Muskeget, however, has made out nearly a quarter of a mile; and a new beach, somewhat further east, but outside of all the other beaches as they formerly existed, has been formed.

These changes show that the action of the currents, breakers, &c., does not entirely carry away these sands, but that the causes which originally formed them tend to keep them in their general position, excepting a gradual working northward, and a tendency to beat in towards the main land.

I remain, sir, very respectfully yours,

HENRY L. WHITING.

Prof. A. D. Bache,

Superintendent U. S. Coast Survey, Washington, D. C.

APPENDIX No. 14.

Report of Lieut. Comg. J. N. Maffitt, U. S. N., assistant in the Coast Survey, on the changes affecting the entrance to North Edisto river, South Carolina.

JAMES RIVER, *August* 26, 1856.

DEAR SIR: The following deductions are based upon a careful comparison of the survey of North Edisto bar made in 1851, and a resurvey of this year.

The general formation of the bar has not been much altered since the survey of 1851, though the position of the two channels has somewhat changed. The entrance to the south channel from sea-ward remains the same, but the inner entrance has been narrowed about two hundred and thirty metres, by the encroachment of the bank on the south side; several twelve-foot spots of the former survey seem to have disappeared, and the channel now shows thirteen feet at mean low water. The outer entrance to the east channel has shifted to the southward and westward about two hundred metres, and has widened about fifty metres; the inner entrance has shifted to the northward and eastward about one hundred metres, thus altering materially the range of the channel. The shoal or middle ground between the channels has somewhat enlarged, and shifted its general position to the southward and westward about two hundred metres. The six-foot curve remains nearly the same. On the south side of the south channel it has shifted to the northward about a hundred metres.

The comparison sheet exhibits the curves taken from the charts of 1851 and 1856.

I am, very respectfully, your obedient servant,

J. N. MAFFITT, *Lieutenant Commanding.*

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey, Washington, D. C.

APPENDIX No. 15.

Report of Lieut. Comg. J. N. Maffitt, U. S. N., assistant in the Coast Survey, on the development of a new channel between Martin's Industry and the southeast breaker, (Port Royal entrance,) South Carolina.

JAMES RIVER, *August* 26, 1856.

DEAR SIR: During the progress of the hydrography of "Martin's Industry," a channel, unknown to the pilots and unnoticed by the best authority, was developed, and, I think, may fairly be claimed as a discovery by the Coast Survey. The most authentic and recent chart of this locality, made a few years ago by Captain Bythwood, of Beaufort, S. C., gives no indication of the channel referred to, nor is there mention made of it in the "Coast Pilot." This channel lies between "Martin's Industry" shoal and the southeast breaker. The old east channel is two miles to the northward of it, and the main or south channel two and three-quarter miles to the southward and westward. Through the "southeast," or Coast Survey channel, there is a depth of twenty feet at mean low water, with an average width of three-quarters of a mile. The course of the channel is northwest and southeast. I herewith enclose a tracing of the channel ways over Port Royal bar, and would respectfully suggest that five buoys be placed as per diagram, in order that the east and south channels may be navigated with safety by vessels under the necessity of using Port Royal as a harbor of refuge.

I am, very respectfully, your obedient servant,

J. N. MAFFITT, *Lieutenant Commanding.*

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey, Washington, D. C.

APPENDIX No. 16.

Letter from the Superintendent to the Secretary of the Treasury, with copy of a communication from Captain W. L. Dall, P. M. S. S. "Columbia," and extracts from a letter of Captain James Watkins, P. M. S. S. "Golden Age," relative to facilities for navigation afforded by the development of a deposit of reddish sand detected by Commander Alden inside of the bar at the entrance to San Francisco harbor, California.

COAST SURVEY OFFICE, *May* 7, 1856.

SIR: I have the honor to subjoin, herewith, the copy of a letter addressed by Captain W. L. Dall, of the Pacific mail steamship "*Columbia,*" to Commander James Alden, U. S. N., assistant in the Coast Survey, in relation to the development by the last named officer of a deposit of sand peculiar to the inside of the bar at the entrance to the harbor of San Francisco, and which was made the general subject of my communication to the Department under date October 20, 1855.

In addressing Commander Alden, Captain Dall says:

"After completing the survey of the entrance to the harbor of San Francisco, you were kind enough to show me your chart, and point out to me the characteristic soundings; you called my attention particularly to the fact, that, as soon as the '*bar*' was crossed, the lead would bring up *gray sand with red specks*, and that such bottom was found at no place outside the bar.

"Since then, I have had on two occasions an opportunity to use the information acquired from your chart.

"In October of last year, coming from the Columbia river, I made Point Arena, (ninety-five miles from the 'Heads,') and at the same time met a dense fog. I ran by time and the revolutions of the wheels until I was up with Point Reyes, when the course was altered for the 'Heads.' To be certain of my position, I got a cast of the lead every fifteen minutes. In four hours after passing Point Reyes I found myself in five fathoms, which I supposed to be on the 'North Bank,' forming part of the bar off San Francisco harbor. Steering E.S.E., and sounding carefully, the water soon deepened to ten fathoms, when I had the lead armed, and it brought up '*gray sand with red specks.*' I was certain then (relying on your chart) that I was inside the bar, and off the entrance of the harbor. I kept the same course until we got eighteen fathoms, when I hauled up N.E. by E., and in a short time got the soundings under the north shore, then altered the course to E. by N., which took me in clear of Fort Point, and the first thing I saw through the fog was the long wharf on North beach.

"On my last trip from Oregon I made Point Reyes at midnight, and saw the light on Point Boneta at intervals. At 2 a. m., when about ten miles from the 'Heads,' the fog shut down so dense, that we could not see a ship's length. I continued on until, by the soundings, we were on the 'North Bank,' and in four and a half fathoms. I then dropped a kedge and waited for daylight. At 5 a. m. got under way, steering E.S.E., and sounding we soon got eight fathoms, and the lead being armed brought up '*gray sand with red specks.*' When in fifteen fathoms, I changed the course to E. by N., and soon, by the deep water, supposed I was in mid-channel. When the fog lifted we were running fairly up the channel, and midway between Fort Point and North shore. Had I not been guided by what I had learned from your chart, I should in both instances have had to remain at anchor outside until the fog lifted.

"Three years ago I was off the harbor in this steamer three days in a dense fog. Had the soundings and peculiarities of the bottom been as well known then as now, I should have been able to run in by the lead. The chart of the entrance of the harbor of San Francisco will be an invaluable assistant to the captains of steamers running on this coast, saving much time during the foggy season, and enabling them, with proper caution, to enter the harbor at times when, without it, they would be obliged to wait outside for clear weather."

Captain James Watkins, of the Pacific Mail Company's steamship "*Golden Age*," in transmitting to me a copy of the communication just quoted, remarks, in regard to the facilities for navigation to be afforded by the publication of the development referred to:

"A short time prior to my leaving San Francisco, I crossed the 'bar' on board the U. S. steamer '*Active*,' and I was highly gratified to know that the 'bar' chart, when published, will furnish us a safe guide into the harbor in thick weather with our lead. As the soundings are so marked and accurate, there can be no mistaking them, in my opinion, with proper attention to the lead."

I would respectfully request authority to publish this communication in the usual form, for the benefit of navigators on the western coast of the United States.

Very respectfully, yours,

A. D. BACHE,
Superintendent.

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

APPENDIX No. 17.

Tide tables for the use of navigators, prepared from the Coast Survey observations by A. D. Bache, Superintendent.

The following tables will enable navigators to ascertain the time and height of high and low water at some of the principal ports of the United States. The results are approximate, the observations being still in progress, but they may safely be used for practical purposes. The number of places of observation, and the time during which many of them have been made, are steadily on the increase as the Coast Survey advances.

The tides of the coast of the United States, on the Atlantic, Gulf of Mexico, and Pacific, are of three different classes. Those of the Atlantic are of the most ordinary type, ebbing and flowing twice in twenty-four hours, and having but moderate differences in height between the two successive high waters or low waters—one occurring before noon, and the other after noon. Those of the Pacific coast also ebb and flow twice during twenty-four hours; but the morning and afternoon tides differ very considerably in height, so much so that at certain periods a rock, which has three feet and a half water upon it at low tide, may be awash at the next succeeding low water. The intervals, too, between successive high or successive low waters may be very unequal. The tides of ports in the Gulf of Mexico, west of Cape St. George, ebb and flow, as a rule, but once in twenty-four hours, or are single-day tides. At particular parts of the month there are two small tides in the twenty-four hours. The rise and fall in all these ports is small. East of Cape St. George the rise and fall increases; there are two tides, as a rule, during the twenty-four hours, and the daily inequality, referred to in the Pacific tides, is large. These peculiarities require a different way of treating the cases, and in some of them separate tables.

I propose to enable the navigator to find, from the Nautical Almanac and the following tables, the time and height of high and low water at any date within the ordinary range of difference produced by winds and other variable circumstances. I will endeavor to divest the matter of unfamiliar technical expressions as far as practicable, though, for brevity, some such terms may be employed after defining them. The discussion of the Gulf tides has not been carried so far as to enable me to present the results in as definite a form as the others.

As is well known, the interval between the time of the moon's crossing the meridian (moon's transit) and the time of high water at a given place is nearly constant; that is, this interval varies between moderate limits, which can be assigned. The interval at full and change of the moon is known as the ***establishment*** of the port, and is ordinarily marked on the charts. As it is not generally the average of the intervals during a month's tides, it is a less convenient and less accurate quantity for the use of the navigator than the average interval which is used on the Coast Survey charts, and is sometimes called the "*mean*," or "*corrected establishment*."*

The following table gives the principal tidal quantities for the different ports named in the first column, where they are arranged under specific heads. The third column of the table gives the mean interval, in hours and minutes, between the moon's transit and the time of high water next after the transit; the fourth, the difference between the greatest and least interval, occurring in different parts of the month, (lunar.) A simple inspection of this column will show how important it is to determine these changes in many of the ports where they amount to more than half an hour, or to more than fifteen minutes, for the average interval.

The fifth, sixth, and seventh columns refer to the height of the tide. The fifth gives, in feet, the average rise and fall, or average difference between high and low water. The sixth gives the greatest difference, commonly known as the rise and fall of spring tides; and the seventh the least difference, known as the rise and fall of neap tides.

The average duration of the flood, or rising tide, is given in the eighth column; of the ebb, or falling tide, in the ninth; and of the period during which the tide neither rises nor falls, or the "stand," in the tenth. The duration of flood is measured from the middle of the stand at low water to the middle of the stand at high water, so that the whole duration from one high water to the next, or from one low water to the next, should be given by the sum of numbers in the eighth and ninth columns.

At most of these places given in the list, a mark of reference has been established for the height of the tide. I have omitted the description of these marks, (except in special localities, designated on the following page,) as of no particular interest in this connection.

* This term was introduced by the Rev. Mr. Whewell, who has done so much for the investigation of the laws of the tides.

BENCH-MARKS.

[Referred to in Table I.]

* *Boston.*—The top of the wall or quay, at the entrance to the dry dock in the Charlestown navy yard, is fourteen feet $\frac{76}{100}$ (14.76 feet) above mean low water.

† *New York.*—The lower edge of a straight line cut in a stone wall, at the head of the wooden wharf on Governor's island, is fourteen feet $\frac{51}{100}$ (14.51 feet) above mean low water. The letters U. S. C. S. are cut in the same stone.

‡ *Old Point Comfort, Va.*—A line cut in the wall of the light-house, one foot from the ground, on the S. W. side, is eleven feet (11 feet) above mean low water.

§ *Charleston, S. C.*—The outer and lower edge of embrasure of gun No. 3, at Castle Pinckney, is ten feet $\frac{13}{100}$ (10.13 feet) above mean low water.

TABLE I.

Tide table for the coast of the United States.

Port.	State.	Interval between time of moon's transit and time of high water.		Rise and fall.			Mean duration.		
		Mean interval.	Difference between greatest and least intervals.	Mean.	Spring tides.	Neap tides.	Flood tide.	Ebb tide.	Stand.
(1.)	(2.)	(3.)	(4.)	(5.)	(6.)	(7.)	(8.)	(9.)	(10.)
Coast from Portland to New York.		h. m.	h. m.	Feet.	Feet.	Feet.	h. m.	h. m.	h. m.
Portland	Me	11 25	0 44	8.8	10.0	7.6	6 14	6 12	0 20
Portsmouth	N. H.	11 23	53	8.6	9.8	7.2	6 22	6 7	21
Newburyport	Mass	11 22	50	7.8	9.1	6.6	5 16	7 9	24
Salem	Mass	11 13	50	9.2	10.6	7.6	6 19	6 6	6
Boston light	Mass	11 12	35	9.3	10.9	8.1	6 20	6 6	15
Boston*	Mass	11 27	44	10.0	11.3	8.5	6 13	6 13	9
Nantucket	Mass	12 24	37	3.1	3.6	2.6	6 23	5 44	9
Edgartown	Mass	12 16	....	2.0	2.5	1.6	6 51	5 29	24
Holmes' Hole	Mass	11 43	31	1.7	1.8	1.3	6 41	5 21	12
Tarpaulin Cove	Mass	8 4	49	2.4	2.6	2.0	6 9	6 17	31
Wood's Hole, N. side	Mass	8 6	....	3.9	....	....	6 31	5 51	....
Wood's Hole, S. side	Mass	8 56	....	1.5	....	....	6 3	6 22	....
Bird island light	Mass	7 59	45	4.4	5.3	3.5	6 51	5 58	....
New Bedford entrance, (Dumpling Rock).	Mass	7 57	41	3.8	4.6	2.8	6 50	5 33	42
Newport	R. I.	7 45	24	3.9	4.6	3.1	6 21	6 3	23
Point Judith	R. I.	7 32	46	3.1	3.7	2.6	6 12	6 10	1 00
Block island	R. I.	7 36	41	2.8	3.5	2.0	6 23	6 2	5
Montauk Point, L. I.	N. Y.	8 20	1 11	1.9	2.4	1.8	6 17	6 7	31
Sandy Hook	N. J.	7 29	47	4.8	5.6	4.0	6 10	6 15	16
New York†	N. Y.	8 13	46	4.3	5.4	3.4	6 00	6 25	28
Tarrytown	N. Y.	9 57	58	3.5	4.0	2.7	6 6	6 20	43
Long Island sound.									
Watch Hill	R. I.	9 00	23	2.7	3.1	2.4	6 35	5 56	14
Stonington	Conn	9 7	30	2.3	3.4	2.1	6 15	6 10	25
Little Gull island	N. Y.	9 38	1 7	2.5	2.9	2.3	6 1	6 21	37
New London	Conn	9 28	52	2.6	3.1	2.1	5 56	6 26	22
New Haven	Conn	11 16	1 8	5.8	6.6	5.1	6 24	6 5	....
Bridgeport	Conn	11 11	1 3	6.5	8.0	4.7	6 1	6 7	....
Oyster Bay, L. I.	N. Y.	11 7	51	7.3	9.2	5.4	6 8	6 24	....
Sand's Point, L. I.	N. Y.	11 13	31	7.7	8.9	6.4	5 55	6 30	14
New Rochelle	N. Y.	11 22	32	7.6	8.6	6.6	5 51	6 35	12
Throg's Neck	N. Y.	11 20	39	7.3	9.2	6.1	5 50	6 33	43
Coast of New Jersey.									
Cold Spring inlet	N. J.	7 32	51	4.4	5.4	3.6	6 8	6 18	....
Cape May landing	N. J.	8 19	47	4.8	6.0	4.3	6 11	6 15	20
Delaware bay and river.									
Delaware Breakwater	Del.	8 00	50	3.5	4.5	3.0	6 15	6 6	26
Higbee's, (Cape May)	N. J.	8 33	43	4.9	6.2	3.9	6 26	6 00	....
Egg Island light	N. J.	9 4	51	6.0	7.0	5.1	5 52	6 27	....
Mahon river	Del.	9 52	48	5.9	6.9	5.0	6 11	6 11	....
New Castle	Del	11 53	....	6.5	6.9	6.6	5 6	6 43	47
Philadelphia	Pa	13 18	48	6.0	6.8	5.1	4 52	7 6	....

TABLE I—Continued.

Port.	State.	Interval between time of moon's transit and time of high water.		Rise and fall.			Mean duration.		
		Mean interval.	Difference between greatest and least intervals.	Mean.	Spring tides.	Neap tides.	Flood tide.	Ebb tide.	Stand.
(1.)	(2.)	(3.)	(4.)	(5.)	(6.)	(7.)	(8.)	(9.)	(10.)
Chesapeake bay and rivers.		*h. m.*	*h. m.*	*Feet.*	*Feet.*	*Feet.*	*h. m.*	*h. m.*	*h. m.*
Old Point Comfort‡	Va	8 17	50	2.5	3.0	2.0	6 1	6 25	....
Point Lookout	Md	12 58	45	1.4	1.9	0.7	5 59	6 19	35
Annapolis	Md	16 38	40	0.9	1.0	0.8	6 11	6 15	32
Bodkin light	Md	17 42	48	1.0	1.3	0.8	5 23	7 8	....
Baltimore	Md	18 33	43	1.3	1.5	0.9	5 54	6 33	....
James river, (City Point)	Va	14 14	....	2.6	....	....	5 28	6 52	40
Richmond	Va	16 28	....	2.9	....	....	4 52	7 34	....
Coast of North and South Carolina, Georgia, and Florida.									
Hatteras inlet	N. C	7 4	57	2.0	2.2	1.8	6 7	6 7	50
Beaufort, N. C	N. C	7 26	50	2.8	3.3	2.2	6 11	6 10	42
Bald Head	N. C	7 26	34	4.3	5.0	3.4	6 18	6 17	31
Smithville, (Cape Fear)	N. C	7 19	47	4.5	5.5	3.8	6 1	6 26	26
Charleston, (Castle Pinckney)§	S. C.	7 13	36	5.3	6.3	4.6	6 36	6 9	33
Fort Pulaski, (Sav. entrance)	Ga	7 20	41	7.0	8.0	5.9	5 49	6 35	26
Savannah, (Dry Dock wharf)	Ga	8 13	51	6.5	7.6	5.5	5 4	7 22	14
Doboy light-house	Ga	7 33	55	6.6	7.8	5.4	6 2	6 20	....
St. Simon's	Ga	7 23	44	6.1	7.3	5.0	4 57	7 36	19
Fort Clinch	Fla	7 53	1 6	5.9	6.7	5.3	6 9	6 17	....
St. John's river	Fla	7 31	48	4.6	5.5	3.2	5 59	6 26	15
St. Augustine	Fla	8 32	43	4.2	4.7	3.5	6 7	6 19	35
Cape Florida	Fla	8 16	51	1.5	1.7	1.2	6 00	6 25	45
Indian Key	Fla	8 18	49	1.8	2.4	1.2	6 36	5 48	19
Sand Key	Fla	8 40	....	1.2	2.0	0.6	6 31	5 55	13
Key West	Fla	9 22	1 12	1.4	2.3	0.7	6 59	5 25	12
Tortugas	Fla	9 56	1 32	1.2	1.5	0.6	6 43	5 40	....
Tampa bay, (Egmont Key)	Fla	11 21	1 33	1.4	1.8	1.0	6 36	6 11	43
Cedar Keys, (Depot Key)	Fla	13 15	1 55	2.5	2.8	1.8	6 12	6 13	....
St. Mark's	Fla	13 33	2 00	2.2	2.9	1.2	6 16	6 9	....
Western coast.									
San Diego	Cal	9 50	1 45	3.7	5.0	2.3	6 22	6 00	30
San Pedro	Cal	9 45	1 48	3.9	4.7	2.2	6 18	6 5	30
Cuyler's harbor	Cal	9 25	1 2	3.7	5.1	2.8	6 13	6 5	....
San Luis Obispo	Cal	10 14	1 52	3.6	4.8	2.4	6 37	5 50	....
Monterey	Cal	10 28	49	3.4	4.3	2.5	6 31	6 2	35
South Farallon	Cal	10 37	1 16	3.6	4.4	2.8	6 18	6 9	....
San Francisco, (N. beach)	Cal	12 6	1 4	3.6	4.3	2.8	6 39	5 51	34
Bodega	Cal	11 17	1 54	3.6	4.7	2.7	6 19	5 59	....
Humboldt bay	Cal	12 02	1 11	4.4	5.5	3.5	6 19	6 00	....
Port Orford	Or. Ter	11 26	1 6	5.1	6.8	3.7	6 19	6 7	39
Astoria	Or. Ter	12 48	1 13	6.1	7.3	4.5	6 3	6 28	33
Neé-ah harbor	W. Ter	12 33	1 28	5.6	7.4	4.8	6 20	6 6	....
Port Townshend	W. Ter	3 49	1 3	4.6	5.5	4.0	6 34	5 52	....
Fort Steilacoom	W. Ter	4 46	1 6	9.2	11.1	7.2	6 3	6 25	28

NOTE.—The mean interval in column 3 has been increased by 12 hours for some of the ports in Delaware river and Chesapeake bay, so as to show the succession of times from the month; therefore, 12 hours ought to be subtracted from the establishments which are greater than 12 hours before using them.

The foregoing Table I gives the means of determining roughly the time and height of high water at the several ports named. The hour of transit of the moon preceding the time of high water is to be taken from the Almanac, and the mean establishment being added, the time of high water results. Thus:

Example I.—It is required to find the time of high water at New York on the 5th of November, 1854. The American Almanac gives *0h. 0m.* as the time of transit of the moon on that day. The mean interval for New York, from Table I, column 3, is *8h. 13m.*, which, as the transit was at *0h.*, is roughly the time of high water.

The moon being full, the height is that of spring tides of column 6, namely, 5.4 feet. If the soundings on the chart are reduced to low water spring tides, 5.4 feet is to be added to them to give the depth at high water. If the soundings are reduced to mean low water, the rise and fall for mean tides being 1.1 foot less than for springs, the rise or increase of depth will be half of this, or 0.6 of a foot less than 5.4 feet, which is 4.8 feet, or nearly 4 feet 10 inches.

Example II.—Required the time of high water at Boston on the 23d of January, 1851. From the American Almanac we find the time of the moon's southing, or transit, on that day 5*h*. 18*m*. a. m., and from Table I the mean interval at Boston dry dock is 11*h*. 27*m*.

We have then 5*h*. 18*m*. time of transit; to which add

11 27 mean interval from Table I.

16 45 time of high water, or 4*h*. 45*m*. p. m.

If the Greenwich Nautical Almanac is used, add 2*m*. to the time of transit of Greenwich for every hour of west longitude, and its proportional part for less than an hour. It will suffice to take the half hour which may be over any number of hours, as the correction for less than this would be less than one minute, and need not be taken into account. Thus Boston is 4*h*. 44*m*. W. of Greenwich. The correction to be applied to the time of transit of the moon at Greenwich is, for the 4*h*., eight minutes, and for the 44*m*., one minute. The time of transit on the date assumed in the preceding example is 5*h*. 9*m*., to which add nine minutes, the correction just found, gives 5*h*. 18*m*., as before ascertained from the American Almanac.

In using the United States Nautical Almanac, in the astronomical part of which the transits of the moon are given for the meridian of Washington, the corrections required may, in this first approximation for the Atlantic coast, be neglected.

To find the time of the next following low water, add from Table I the duration of ebb tide; this gives 4*h*. 45*m*. p. m., time of high water.

6 13 duration of ebb tide from Table I.

10 58 p. m.

By subtracting the duration of flood tide, we obtain the time of the preceding low water, 10*h*. 32*m*. a. m., recollecting that 4*h*. 45*m*. p. m. is the same as 16*h*. 45*m*. reckoned from midnight.

The height of this tide corresponding to the transit of 5*h*. will bring it nearly to a neap tide, and the rise and fall, obtained from column 7, Table I, is 8.5 feet.

The next following high water may be had by adding to the time of low water the duration of flood, from Table I, thus: 10*h*. 58*m*. p. m , time of low water, January 23.

6 13 duration of flood from Table I.

Sum 17 11 or 5*h*. 11*m*. a. m., on January 24.

Or, having found the time of high water, the time of the next following high water may be found by adding the duration of flood and of ebb together, and their sum to the time of high water found. Thus:

6*h*. 13*m*., duration of ebb tide from Table I.

6 13 duration of flood.

12 26 duration of whole tide.

4 45 p. m., January 23, time of high water.

17 11 or 5*h*. 11*m*. a. m., 24th January, time of the next succeeding high water. Subtracting the same quantity, will give the time of the preceding high water. Thus:

4*h*. 45*m*. p. m., or 16*h*. 45*m*. from midnight, is the time of high water.

12 26 duration of flood and ebb.

4 19 a. m. of the 23d for the preceding high water. The duration of the flood and ebb having been reckoned from the middle of one stand or slack-water to the middle of the next, the time of beginning of stand of ebb or flood will be found by subtracting half the duration of stand or slack-water given by column 10, Table I, from the time of high or low water, and the time of the end of stand of ebb or flood by adding the same. A nearer approximation to the times and heights of high water may be obtained by the use of Tables II and III.

TABLE II.

Interval between the time of moon's transit and the time of high water for different hours of trai. sit, and for several different ports.

Time of moon's transit.	Boston.	New York.	Philadelphia.	Old Point Comfort, Va.	Baltimore, Md.	Smithville, N. C.	Charleston, S. C.	Ft. Pulaski, Savannah R., Ga.	Key West, Fla.	San Francisco, Cal.
h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
0 0	11 38	8 20	1 31	8 33	6 47	7 26	7 38	7 30	9 26	12 5
0 30	11 33	8 18	1 28	8 27	6 42	7 21	7 34	7 25	9 19	11 59
1 0	11 28	8 15	1 25	8 21	6 37	7 16	7 28	7 19	9 12	11 53
1 30	11 24	8 10	1 21	8 15	6 31	7 13	7 22	7 15	9 6	11 47
2 0	11 20	8 06	1 18	8 9	6 26	7 9	7 16	7 11	9 0	11 41
2 30	11 16	8 0	1 14	8 4	6 21	7 6	7 11	7 8	8 55	11 36
3 0	11 13	7 55	1 11	8 0	6 17	7 4	7 7	7 6	8 51	11 33
3 30	11 10	7 52	1 8	7 56	6 13	7 3	7 3	7 5	8 50	11 33
4 0	11 07	7 52	1 6	7 52	6 11	7 2	7 0	7 4	8 49	11 38
4 30	11 06	7 52	1 3	7 49	6 10	7 3	6 58	7 3	8 53	11 46
5 0	11 06	7 53	1 0	7 48	6 10	7 4	6 58	7 4	8 57	11 55
5 30	11 09	7 56	0 59	7 50	6 13	7 6	6 59	7 6	9 7	12 3
6 0	11 13	7 59	0 59	7 53	6 19	7 9	7 1	7 8	9 17	12 11
6 30	11 19	8 05	1 1	8 0	6 25	7 13	7 4	7 12	9 28	12 16
7 0	11 25	8 11	1 7	8 7	6 32	7 17	7 10	7 16	9 39	12 23
7 30	11 32	8 17	1 15	8 15	6 39	7 23	7 19	7 22	9 45	12 29
8 0	11 38	8 23	1 23	8 24	6 44	7 28	7 28	7 28	9 52	12 34
8 30	11 43	8 27	1 29	8 33	6 49	7 33	7 36	7 34	9 54	12 37
9 0	11 47	8 32	1 34	8 40	6 52	7 37	7 42	7 39	9 56	12 36
9 30	11 48	8 34	1 39	8 45	6 54	7 39	7 45	7 42	9 53	12 34
10 0	11 49	8 35	1 42	8 48	6 53	7 40	7 48	7 43	9 51	12 30
10 30	11 48	8 34	1 43	8 48	6 52	7 40	7 48	7 41	9 45	12 24
11 0	11 47	8 31	1 41	8 46	6 50	7 36	7 46	7 37	9 39	12 17
11 30	11 43	8 25	1 37	8 40	6 48	7 30	7 42	7 34	9 32	12 9

TABLE III.

Showing the rise and fall of tides, and corrections to be applied to determine the height of high water soundings on charts referring to mean low water, and to low water spring tides.

Time of moon's transit.	Boston.			New York.			Philadelphia.			Old Point Comfort, Va.			Baltimore, Md.			Time of moon's transit.
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Hour.*
0	11.2	10.6	11.3	4.9	4.5	4.9	6.3	6.2	6.3	2.9	2.6	2.9	1.5	1.4	1.6	0
1	11.3	10.6	11.3	4.9	4.5	4.9	6.4	6.4	6.5	3.0	2.7	3.0	1.5	1.4	1.6	1
2	11.2	10.5	11.2	4.7	4.4	4.8	6.6	6.5	6.6	2.9	2.7	2.9	1.5	1.3	1.5	2
3	10.6	10.3	11.0	4.3	4.2	4.6	6.6	6.5	6.6	2.6	2.6	2.8	1.4	1.3	1.5	3
4	10.0	10.0	10.7	3.8	4.0	4.4	6.4	6.4	6.5	2.3	2.4	2.7	1.3	1.2	1.4	4
5	9.2	9.7	10.4	3.5	3.8	4.2	6.1	6.2	6.3	2.1	2.3	2.6	1.1	1.1	1.3	5
6	8.8	9.4	10.1	3.3	3.7	4.1	5.7	5.9	6.0	2.0	2.2	2.5	0.9	1.1	1.3	6
7	8.6	9.3	10.0	3.3	3.7	4.1	5.4	5.6	5.7	2.0	2.3	2.5	0.9	1.1	1.3	7
8	8.9	9.5	10.2	3.6	3.8	4.2	5.2	5.3	5.4	2.2	2.4	2.6	1.0	1.2	1.4	8
9	9.4	9.7	10.4	4.0	4.0	4.4	5.4	5.4	5.5	2.1	2.5	2.8	1.1	1.3	1.5	9
10	10.1	10.0	10.7	4.5	4.3	4.7	5.7	5.7	5.8	2.8	2.7	2.9	1.3	1.4	1.6	10
11	10.7	10.3	11.0	4.8	4.5	4.9	6.0	6.0	6.1	3.0	2.8	3.0	1.4	1.4	1.6	11

TABLE III—Continued.

Time of moon's transit.	Smithville, N. C.			Charleston, S. C.			Tybee Entrance, Ga.			Key West, Fla.			San Francisco, Cal.			Time of moon's transit.
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Hour.*
0	5.2	4.8	5.1	5.7	5.4	5.7	7.8	7.4	7.8	1.6	1.4	1.6	4.5	4.0	4.4	0
1	5.1	4.8	5.1	5.8	5.4	5.7	7.9	7.4	7.9	1.6	1.4	1.6	3.9	3.7	4.1	1
2	5.0	4.7	5.0	5.6	5.4	5.7	7.6	7.3	7.7	1.5	1.4	1.5	3.7	3.6	4.1	2
3	4.6	4.5	4.8	5.5	5.3	5.6	7.1	7.0	7.5	1.4	1.3	1.5	3.5	3.5	4.0	3
4	4.3	4.4	4.7	5.2	5.2	5.5	6.5	6.7	7.2	1.2	1.2	1.4	3.1	3.3	3.8	4
5	4.0	4.3	4.6	4.9	5.1	5.4	6.1	6.5	7.0	1.0	1.1	1.3	2.8	3.1	3.6	5
6	3.8	4.2	4.5	4.8	5.0	5.3	5.8	6.4	6.8	1.0	1.1	1.3	2.7	3.1	3.6	6
7	3.8	4.1	4.4	4.7	4.9	5.2	6.0	6.5	6.9	1.0	1.1	1.3	3.0	3.3	3.7	7
8	4.0	4.2	4.5	4.8	5.0	5.3	6.4	6.7	7.1	1.1	1.2	1.3	3.4	3.5	3.9	8
9	4.3	4.3	4.6	4.9	5.1	5.4	6.9	6.9	7.4	1.3	1.3	1.4	3.8	3.6	4.1	9
10	4.7	4.6	4.9	5.2	5.3	5.6	7.4	7.0	7.6	1.4	1.3	1.5	4.0	3.8	4.2	10
11	5.0	4.7	5.0	5.5	5.4	5.8	7.8	7.2	7.8	1.6	1.4	1.6	4.2	3.8	4.3	11

In these, the variations in the interval between the moon's transit and high water are shown for some of the principal ports contained in Table I. These variations of interval depend upon the age of the moon, and, as they go through their values in half a lunar month, are known as the half-monthly inequality of interval. The table extends from 0*h.* of transit, midnight of the calendar day, or full of the moon, to $11\frac{1}{2}$ hours. The numbers for "change" of the moon correspond to those for 0 hours, and for 13 hours (or 1 p. m. of the calendar day) to 1 hour, and so on up to 23 hours. The ports for which the numbers are given are designated by the heading of the columns.

The mean interval, it will be seen, does not occur at full and change, but nearly two days afterwards, on the Atlantic Coast. At Key West it occurs more nearly at full and change, and at San Francisco still more nearly.

The same remark applies to the heights; spring tides occur about two days after the full and change of the moon, and neaps two days after the first and last quarter.

The use of this table of nearer approximation is quite as simple as that of Table I.

Rule to find the time of high water.—Look in the Almanac for the time of moon's transit, (or southing) for the date required. In the table corresponding to that time will be found the number to be added to the time of transit.

Example III.—Required the time of high water at New York, October 1, 1856. Using the United States Nautical Almanac, we find the time of moon's transit 1*h.* 24*m.*, astronomical reckoning, or 1*h.* 24*m.* p. m., calendar time. From Table II, we have under the heading of New York, for 1*h.* 30*m.*, (the nearest number to 1*h.* 24*m.* in the table,) 8*h.* 10*m.*

Thus to	1*h.*	24*m.*,	time of moon's transit,
Add	8	10	interval found from Table II.
The sum,	9	34	p. m., is the time of high water on the 1st of October, 1856.

If the sum of these numbers had exceeded twelve, the tide would have belonged to October 2d, and we must have gone back to the transit of the day before and computed with it, to obtain the tide for October 1st.

Rule to find the height of high water.—Enter Table III, column 1, with the time of moon's transit. In the column headed with the name of the place, and marked A, will be found the rise and fall corresponding to the time of transit; in column B, the number to be added to soundings on the chart, where the soundings are given for mean low water; in column C, the number to be added to charts of which the soundings are given for low water, spring tides.

In the foregoing example, (III,) the time of transit being between 1 and 2 hours, we find, from Table III, the rise and fall of the tide on the 1st of October, 1856, between 4.9 and 4.7; the number to be added to soundings given for mean low water 4.5 feet, (column B,) and for low water spring tides, (column C,) 4.9 feet.

Having found the time of high water, that of low water may be obtained nearly by adding the duration of the ebb from column 9, Table I. The time of the next preceding low water may be found by subtracting the duration of flood from column 8, Table I. The time of the next following high water may be found by adding the duration of both flood and ebb, and of the next preceding high water, by subtracting the same duration of the whole tide.

Example IV.—To find the next high water following that of Example III.

The duration of flood, column 8, Table I, for New York, is 6*h.* 0*m.*; and of ebb, from column 9, is 6*h.* 25*m.*; the sum is 12*h.* 25*m.*

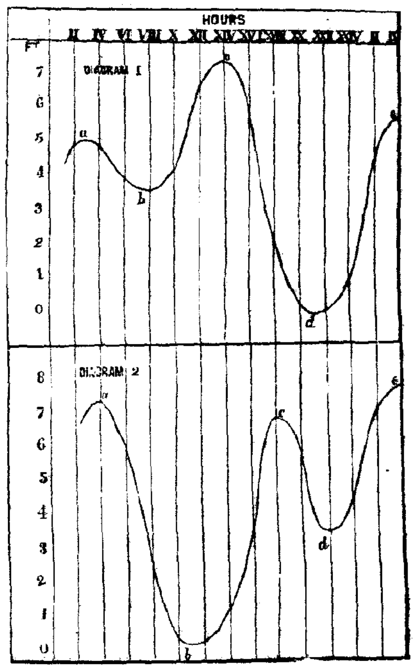
To	9*h.*	34*m.*	p. m., October 1, the time of high water found,
Add	12	25	duration of flood and ebb.
Sum,	21	59,	or 9*h.* 59*m.* a. m. of October 2, the time of the next high water.

TIDES OF THE PACIFIC COAST.

On the Pacific Coast there is, as a general rule, one large and one small tide during each day, the heights of two successive high waters occurring one a. m. and the other p. m. of the same twenty-four hours, and the intervals from the next preceding transit of the moon are very different. These inequalities depend upon the moon's declination. When the moon's declination is nothing, they disappear; and when it is the greatest, either north or south, they are greatest. The inequalities for low water are not the same as for high, though they disappear and have the greatest value at nearly the same times.

When the moon's declination is north, the highest of the two high tides of the twenty-four hours occurs at San Francisco about eleven and a half hours after the moon's southing, (transit;) and when the declination is south, the lowest of the two high tides occurs at about that interval.

The lowest of the two low waters of the day is the one which follows next the highest high water. The nature of these tides will probably appear more plainly from the annexed diagrams. In them the height of the tide is set off at the side on a scale of feet, and the hours of the day are at the top. At XII noon, for example, the tide-gauge marked 6.7 feet. Joining all the heights observed in the twenty-four hours, we have a curve like that marked in the figure. The two high waters are *a* and *c*, and the two low waters *b* and *d*. If *a* is the high water, which occurs about twelve hours after the transit of the moon, when the declination is south, the ebb *a b* is quite small, and the high water *a* is much lower than the next high water *c*. If the moon's declination is north, it is the large high water *a* of the second diagram, which occurs next after the transit, and about twelve hours from it.



Tables IV and V give the number to be added to the time of moon's transit to find the time of high water almost as readily as in the former case. It is one of double entry, the time of transit being, as before, placed in the first column. The number of days from the day at which the moon has had the greatest declination are arranged at the top of the table. Entering the first column with the time of transit, until we come under the column containing the days from the greatest declination, we find the number to be added to the time of transit to give the time of high water. If the moon's declination is south, Table IV is to be used; if north, Table V.

Number to be added to the time of moon's transit at San Francisco to give the time of high water for different times of moon's transit, and declination of the moon.

	TABLE IV.								TABLE V.								
Time of moon's transit.	South declination.—Days from greatest declination.								North declination.—Days from greatest declination.								Time of moon's declination.
	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	
h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
0 0	13 5	13 2	12 57	12 50	12 42	12 32	12 19	12 5	11 5	11 8	11 13	11 20	11 28	11 38	11 51	12 5	0 0
0 30	12 59	12 56	12 51	12 44	12 36	12 26	12 13	11 59	10 59	11 2	11 7	11 14	11 22	11 32	11 45	11 59	0 30
1 0	12 53	12 50	12 45	12 38	12 30	12 20	12 7	11 53	10 53	10 56	11 1	11 8	11 16	11 26	11 39	11 53	1 0
1 30	12 47	12 44	12 39	12 32	12 24	12 14	12 1	11 47	10 47	10 50	10 55	11 2	11 10	11 20	11 33	11 47	1 30
2 0	12 41	12 38	12 33	12 26	12 18	12 8	11 55	11 41	10 41	10 44	10 49	10 56	11 4	11 14	11 27	11 41	2 0
2 30	12 36	12 33	12 28	12 21	12 13	12 3	11 50	11 36	10 36	10 39	10 44	10 51	10 59	11 9	11 22	11 36	2 30
3 0	12 33	12 30	12 25	12 18	12 10	12 0	11 47	11 33	10 33	10 36	10 41	10 48	10 56	11 6	11 19	11 33	3 0
3 30	12 33	12 30	12 25	12 18	12 10	12 0	11 47	11 33	10 33	10 36	10 41	10 48	10 56	11 6	11 19	11 33	3 30
4 0	12 38	12 35	12 30	12 23	12 15	12 5	11 52	11 38	10 38	10 41	10 46	10 53	11 1	11 11	11 24	11 38	4 0
4 30	12 46	12 43	12 38	12 31	12 23	12 13	12 0	11 46	10 46	10 49	10 54	11 1	11 9	11 19	11 32	11 46	4 30
5 0	12 55	12 52	12 47	12 40	12 32	12 22	12 9	11 55	10 55	10 58	11 3	11 10	11 18	11 28	11 41	11 55	5 0
5 30	13 3	13 0	12 55	12 48	12 40	12 30	12 17	12 3	11 3	11 6	11 11	11 18	11 26	11 36	11 49	12 3	5 30
6 0	13 11	13 8	13 3	12 56	12 48	12 38	12 25	12 11	11 11	11 14	11 19	11 26	11 34	11 44	11 57	12 11	6 0
6 30	13 16	13 13	13 8	13 1	12 53	12 43	12 30	12 16	11 16	11 19	11 24	11 31	11 39	11 49	12 2	12 16	6 30
7 0	13 23	13 20	13 15	13 8	13 0	12 50	12 37	12 23	11 23	11 26	11 31	11 38	11 46	11 56	12 9	12 23	7 0
7 30	13 29	13 26	13 21	13 14	13 6	12 56	12 43	12 29	11 29	11 32	11 37	11 44	11 52	12 2	12 15	12 29	7 30
8 0	13 34	13 31	13 26	13 19	13 11	13 1	12 48	12 34	11 34	11 37	11 42	11 49	11 57	12 7	12 20	12 34	8 0
8 30	13 37	13 34	13 29	13 22	13 14	13 4	12 51	12 37	11 37	11 40	11 45	11 52	12 0	12 10	12 23	12 37	8 30
9 0	13 36	13 33	13 28	13 21	13 13	13 3	12 50	12 36	11 36	11 39	11 44	11 51	11 59	12 9	12 22	12 36	9 0
9 30	13 34	13 31	13 26	13 19	13 11	13 1	12 48	12 34	11 34	11 37	11 42	11 49	11 57	12 7	12 20	12 34	9 30
10 0	13 30	13 27	13 22	13 15	13 7	12 57	12 44	12 30	11 30	11 33	11 38	11 45	11 53	12 3	12 16	12 30	10 0
10 30	13 24	13 21	13 16	13 9	13 1	12 51	12 38	12 24	11 24	11 27	11 32	11 39	11 47	11 57	12 10	12 24	10 30
11 0	13 17	13 14	13 9	13 2	12 54	12 44	12 31	12 17	11 17	11 20	11 25	11 32	11 40	11 50	12 3	12 17	11 0
11 30	13 9	13 6	13 1	12 54	12 46	12 36	12 23	12 9	11 9	11 12	11 17	11 24	11 32	11 42	11 55	12 9	11 30

If we disregard the daily inequality, the column headed San Francisco, in Table II, would give us, as in the examples on the Atlantic Coast, the means of determining the time of high water. With this, the column for seven days in the present table agrees, as in between six and seven days from the maximum, the declination becomes nothing, and the diurnal inequality also nothing.

Example V.—Required the time of high water at North Beach, San Francisco, Cal., on the 7th of February, 1853.

1st. The time of moon's transit at Greenwich, from the Nautical Almanac, is 11*h.* 41*m.*; the longitude of San Francisco 8*h.* 10*m.*, requiring a correction (see p. 123) of 16*m.* to the time of transit for San Francisco, which is thus found to be 11*h.* 57*m.*

2d. The moon's declination is south, and at the time of transit about two days from the greatest. Entering Table IV, we find 12*h* (or 0*h*) of transit, the nearest number to 11*h.* 57*m.*, which the table gives; and following the line horizontally until we come to two days from the greatest declination, we find 12*h.* 57*m.*

To 11*h.* 57*m.* time of transit of moon, February 7th San Francisco,

Add 12 57 from column 0*h* transit, and two days from greatest declination.

Sum 24 54 or, 0*h.* 54*m.*, February 8, is the time of high water, corresponding to the transit which we took of February 7. If we desire the tide of February 7, we must go back to the moon's transit of the 6th. The example was purposely assumed to show this case.

11*h.* 1*m.* time of transit February 6, 1853.

13 14 number for 11*h.* transit and one day from greatest declination.

Sum 24 15 time of high water 0*h.* 15*m.* a. m., February 7.

The height of high water.—The height of high water is obtained in a similar manner by the use of Tables VI and VII, entering these in the same way with the time of transit and days from the greatest declination. Table VI is for south declination, and Table VII for north.

Table showing the number to be added to the soundings on charts, referred to the mean lowest low waters of day, to give the depth at high water at San Francisco.

TABLE VI. — SOUTH DECLINATION.

Time of moon's transit.	Days from greatest declination: 0	1	2	3	4	5	6	7
h.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	4.0	4.1	4.1	4.2	4.3	4.5	4.8	5.0
1	3.9	4.0	4.0	4.1	4.2	4.4	4.7	4.9
2	3.8	3.9	3.9	4.0	4.1	4.3	4.6	4.8
3	3.6	3.7	3.7	3.8	3.9	4.1	4.4	4.6
4	3.4	3.5	3.5	3.6	3.7	3.9	4.2	4.4
5	3.3	3.4	3.4	3.5	3.6	3.8	4.1	4.3
6	3.3	3.4	3.4	3.5	3.6	3.8	4.1	4.3
7	3.4	3.5	3.5	3.6	3.7	3.9	4.2	4.4
8	3.5	3.6	3.6	3.7	3.8	4.0	4.3	4.5
9	3.7	3.8	3.8	3.9	4.0	4.2	4.5	4.7
10	3.9	4.0	4.0	4.1	4.2	4.4	4.7	4.9
11	4.1	4.2	4.2	4.3	4.4	4.6	4.9	5.1

TABLE VII. — NORTH DECLINATION.

Time of moon's transit.	Days from greatest declination: 0	1	2	3	4	5	6	7
h.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	6.0	5.9	5.9	5.8	5.7	5.5	5.2	5.0
1	5.9	5.8	5.8	5.7	5.6	5.4	5.1	4.9
2	5.8	5.7	5.7	5.6	5.5	5.3	5.0	4.8
3	5.6	5.5	5.5	5.4	5.3	5.1	4.8	4.6
4	5.4	5.3	5.3	5.2	5.1	4.9	4.6	4.4
5	5.3	5.2	5.2	5.1	5.0	4.8	4.5	4.3
6	5.3	5.2	5.2	5.1	5.0	4.[illegible]	4.5	4.3
7	5.4	5.3	5.3	5.2	5.1	[illegible].9	4.6	4.4
8	5.5	5.4	5.4	5.3	5.2	5.0	4.7	4.5
9	5.7	5.6	5.6	5.5	5.4	5.2	4.9	4.7
10	5.9	5.8	5.8	5.7	5.6	5.4	5.1	4.9
11	6.1	6.0	6.0	5.9	5.8	5.6	5.3	5.1

NOTE.—To use these tables with a chart on which the soundings are referred to mean low water, subtract one foot from the numbers in the tables.

Example VI.—In example V, to obtain the height of the tide on February 7, the declination being south, we enter Table VI with 0*h.* of transit and two days from greatest declination, and find that the tide will be 4.1 feet above the mean of lowest low water, or that 4.1 feet are to be added to the soundings of a chart reduced to the mean of the lowest low water of each day. If the soundings of the chart were given for mean low water, then 1.0 foot ought to be subtracted from the numbers in Tables VI and VII; thus, in this example it would be 3.1 feet.

The approximate time of the successive low and high waters of the day will be found by adding the numbers in Table VIII to the time of the first high water already determined. The table gives the numbers for the different days from the greatest declination.

TABLE VIII.

Containing numbers to be added to the time of high water found, from Table III, to obtain the successive low and high waters.

Days from greatest declination.	SOUTH DECLINATION. Low water. (Small.)	High water (Large.)	Low water, (Large.)	NORTH DECLINATION. Low water. (Large.)	High water. (Small.)	Low water. (Small.)	Days from greatest declination.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	
0	4 11	10 24	17 52	7 28	14 26	18 37	0
1	4 17	10 31	17 55	7 24	14 19	18 36	1
2	4 23	10 41	17 58	7 17	14 9	18 32	2
3	4 33	10 55	18 2	7 7	13 55	18 28	3
4	4 45	11 11	18 6	6 55	13 39	18 24	4
5	5 3	11 31	18 8	6 37	13 19	18 22	5
6	5 23	11 58	18 13	6 15	12 52	18 15	6
7	5 49	12 25	18 14	5 49	12 25	18 14	7

The days from greatest declination are written in the first and last columns of the table. The second, third, and fourth columns refer to south declination, and the fifth, sixth, and seventh to north. The second column gives the number which is to be added, according to the declination, to the time of high water, obtained by means of Tables IV and V, to give the next low water; which is the small low water *b* of Diagram I. The third contains the numbers to be added to the same, to give the second or large high-water *c* of Diagram I. The fourth, the numbers to be added to the same, to give the second or large low-water *d* of Diagram I. The succeeding columns give the numbers to be used in the same way for north declinations, to obtain the low-water *b* (large) of Diagram II, the high-water *c* (small,) and the low-water *d* (small,) of the same diagram.

The rise and fall of the same successive tides may be obtained by inspection from Table IX, in which the first column at the side contains the time of transit, and the successive columns the numbers corresponding to that time, and to the number of days from greatest declination. The arrangement of this table is like that already given.

The numbers for the small ebb-tide *a b* of Diagram I, or *c d* of Diagram II, are first given; then these for small low and large high-water *b c* of Diagram I, and *d e* of Diagram II; next, the large ebb-tide *c d* of Diagram I, or *a b* of Diagram II; and lastly, from the large low-water to the small high-water *d e* of Diagram I, or *b c* of Diagram II.

TABLE IX.

Showing the rise and fall of the several tides corresponding to different hours of transit and days from greatest declination of moon at San Francisco.

Hours of moon's transit.	Small ebb-tide, or from small high water to small low water.								From small low water to large high water.							
	Days from maximum declination.								Days from maximum declination.							
	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.4	1.6	1.7	2.1	2.5	3.0	3.7	4.3	3.4	3.4	3.5	3.7	3.9	4.0	4.1	4.3
1	1.2	1.4	1.5	1.9	2.3	2.8	3.5	4.1	3.2	3.2	3.3	3.5	3.7	3.8	3.9	4.1
2	1.0	1.2	1.3	1.7	2.1	2.6	3.3	3.9	3 0	3.0	3.1	3.3	3.5	3.6	3.7	3.9
3	0.7	0.9	1.0	1.4	1.8	2.2	3.0	3.6	2.7	2.7	2.8	3.0	3.2	3.0	3.4	3.6
4	0.2	0.4	0.5	0.9	1.3	1.8	2.5	3.1	2.2	2.2	2.3	2.5	2.7	2.8	2.9	3.1
5	0.0	0.2	0.3	0.7	1.1	1.6	2.3	2.9	2.0	2.0	2.1	2.3	2 5	2.6	2.7	2.9
6	0.1	0.1	0.2	0.6	1.0	1.5	2.2	2.8	1.9	1.9	2.0	2.2	2.4	2.5	2.6	2.8
7	0.2	0.4	0.5	0.9	1.3	1.8	2.5	3.1	2.2	2.2	2.3	2.5	2.7	2.8	2.9	3.1
8	0.5	0.7	0.8	1.2	1.6	2.1	2.9	3.4	2.5	2.5	2.6	2.8	3.0	3.1	3.2	3.4
9	0.9	1.1	1.2	1.6	2.0	2.5	3.2	3.8	2.9	2.9	3.0	3.2	3.4	3.5	3.6	3.8
10	1.2	1.4	1.5	1.9	2.3	2.8	3.5	4.1	3.2	3.2	3.3	3.5	3.7	3.8	3.9	4.1
11	1.5	1.7	1.8	2 2	2.6	3.1	3.8	4.4	3.5	3.5	3.6	3.8	4.0	4.1	4.2	4.4
	From .... *a* to *b*, Diagram I. And from .... *c* to *d*, " II.								From .... *b* to *c*, Diagram I. And from .... *d* to *e*, " II.							

TABLE IX—Continued.

Hours of moon's transit.	Large ebb-tide, or from large high water to large low water.								From large low water to small low water.							
	Days from maximum declination.								Days from maximum declination.							
	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	7.2	7.0	6.9	6.5	6.1	5.6	4.9	4.3	5.2	5.2	5.1	4.9	4.7	4.6	4.5	4.3
1	7.0	6.8	6.7	6.3	5.9	5.4	4.7	4.1	5.0	5.0	4.9	4.7	4.5	4.4	4.3	4.1
2	6.8	6.6	6.5	6.1	5.7	5.2	4.5	3.9	4.8	4.8	4.7	4.5	4.3	4.2	4.1	3.9
3	6.5	6.3	6.2	5.8	5.4	4.9	4.2	3.6	4.5	4.5	4.4	4.2	4.0	3.9	3.8	3.6
4	6.0	5.8	5.7	5.3	4.9	4.4	3.7	3.1	4.0	4.0	3.9	3.7	3.5	3.4	3.3	3.1
5	5.8	5.6	5.5	5.1	4.7	4.2	3.5	2.9	3.8	3.8	3.7	3.5	3.3	3.2	3.1	2.9
6	5.7	5.5	5.4	5.0	4.6	4.1	3.4	2.8	3.7	3.7	3.6	3.4	3.2	3.1	3.0	2.8
7	6.0	5.8	5.7	5.3	4.9	4.4	3.7	3.1	4.0	4.0	3.9	3.7	3.5	3.4	3.3	3.1
8	6.3	6.1	6.0	5.6	5.2	4.7	4.0	3.4	4.3	4.3	4.2	4.0	3.8	3.7	3.6	3.4
9	6.7	6.5	6.4	6.0	5.6	5.1	4.4	3.8	4.7	4.7	4.6	4.4	4.2	4.1	4.0	3.8
10	7.0	6.8	6.7	6.3	5.9	5.4	4.7	4.1	5.0	5.0	4.9	4.7	4.5	4.4	4.3	4.1
11	7.3	7.1	7.0	6.6	6.2	5.7	5.0	4.4	5.3	5.3	5.2	5.0	4.8	4.7	4.6	4.4
	From .... *c* to *d*, Diagram I. And from .... *a* to *b*, " II.								From .... *d* to *e*, Diagram I. And from .... *b* to *c*, " II.							

Example VII.—Thus in Example VI, the high water of February 7 was found to be 3.1 feet above mean low water. The declination being south, Diagram I applies, and this high water is the small one. To obtain the fall of the next low water, or small low water, we enter Table IX with *0h.* of moon's transit, and two days from greatest declination in the first part of the table and find 1.7 foot, which will be the difference in height of this high and low water. Entering with the same transit and day in the second part, we find 3.5 feet, which is the rise of the large high water above the small low water; the difference between 1.7 foot and 3.5 feet, or 1.8 foot, is the difference of height of the two successive high waters.

It is easy to see how, in this way, the soundings of a chart can be reduced to what they would be approximately at all the successive high and low waters. A similar set of tables is in preparation for Key West, and some of the other ports on the Gulf of Mexico, where the tides are of the same character.

The tidal observations now in progress on the Pacific will give the means of extending the tables to all the principal ports there.

TIDES OF THE GULF OF MEXICO.

On the coast of Florida, from Cape Florida round the peninsula to St. Mark's, the tides are of the ordinary kind, but with a daily inequality, which, small at Cape Florida, goes on increasing as we proceed westward to the Tortugas. From the Tortugas to St. Mark's the daily inequality is large and sensibly the same, giving the tides a great resemblance to those of the Pacific coast, though the rise and fall is much smaller. Between St. Mark's and St. George's island, (Apalachicola entrance,) the tide changes to the single-day class, ebbing and flowing but once in the twenty-four (lunar) hours. At St. George's island there are two tides a day for three or four days, about the time of the moon's declination being zero. At other times there is but one tide a day, with a long stand at high water of from six to nine hours. From Cape St. Blas, to and including the mouth of the Mississippi, the single tides are very regular, and the very small and irregular double tides appear only for two or three days (and frequently, even, not at all) about the time of zero declination of the moon; the stand at high and low water is comparatively short, seldom exceeding an hour.

To the west of the mouth of the Mississippi the double tides reappear. At Isle Dernière they are distinct, though a little irregular, for three or four days near the time of moon's zero declination. At all other times the single-day type prevails, the double tides modifying it, however, in the shape of a long stand of from six to ten hours at high water. This stand is shortest at the time of moon's greatest declination, sometimes being even reduced to but an hour. At Calcasieu the tides are distinctly double, but with a large daily inequality. The rise and fall being small, they would often present to the ordinary observer the same appearance as at Isle Dernière. At Galveston the double tides are plainly perceptible, though small, for five or six days, about the time of moon's zero of declination. At other times they present the single-day type, with the peculiarity that, after standing at high water for a short time, the water falls a small distance, and stands again at that height for several hours, then continues to fall to low water. Sometimes it falls very slowly for the nine or ten hours following high water, and then acquires a more rapid rate to low water. At Aransas Pass and Brazos Santiago, the single-day tides prevail. Small irregular double tides are only perceived for two or three days at the moon's zero declination. At other times there is but one high water in the day, with a long stand of from six to nine hours, during which time are often small irregular fluctuations, or a very slow fall. (See description of type curves, Appendix No. 36.)

In the following table the rise and fall of tides at the above stations are given.

The highest high and the lowest low waters occur when the greatest declination of the moon happens at full or change; the least tide when the moon's declination is nothing at the first or last quarter.

The rise and fall being so small, the times and heights are both much influenced by the winds, and are thus often rendered quite irregular.

TABLE X.

Rise and fall of tides at several stations in the Gulf of Mexico.

Stations.	Mean rise and fall of tides.		
	Mean.	At moon's greatest declination.	At moon's least declination.
	Ft.	*Ft.*	*Ft.*
St. George's island, Florida	1.1	1.8	0.6
Pensacola, Florida	1.0	1.5	0.4
Fort Morgan, Mobile bay, Alabama	1.0	1.5	0.4
Cat island, Mississippi	1.3	1.9	0.6
Southwest Pass, Louisiana	1.1	1.4	0.5
Isle Dernière, Louisiana	1.4	2.2	0.7
Entrance to Lake Calcasieu, Louisiana	1.9	2.4	1.7
Galveston, Texas	1.1	1.6	0.8
Aransas Pass, Texas	1.1	1.8	0.6
Brazos Santiago, Texas	0.9	1.2	0.5

The type curves, representing the law of the rise and fall of the tides at the different ports, will be found on Sketch No. 38, and a description of them in Appendix No. 36.

TO DETERMINE THE RISE AND FALL OF THE TIDE FOR ANY GIVEN TIME FROM HIGH OR LOW WATER.

It is sometimes desirable to know how far the tide will rise in a given time from low water, or fall in a given time from high water, or to approximate to the time which has elapsed from low or high water, by knowing the rise or fall of the tide in the interval. If the proportion of the rise and fall in a given time were the same in the different ports, this would easily be shown in a single table, giving the proportional rise and fall, which, by referring to Table I, showing the rise and fall of the tide at the port, would give the rise and fall in feet and decimals. The proportion, however, is not the same in different ports, nor in the same ports for tides of different heights. The following (Table XI) shows the relation between the heights above low water for each half hour for New York and for Old Point Comfort, and for spring and neap tides at each place. Units express the total rise of high water above low water; and the figures opposite to each half hour denote the proportional fall of the tide from high water onward to low water. For example: at New York, three hours after high water, a spring tide has fallen six-tenths (sixty-hundredths) of the whole fall. Suppose the whole rise and fall of that day to be 5.4 feet, (Table I;) then three hours after high water, the tide will have fallen 3.24 feet, or three feet three inches, nearly. Conversely, if we have observed that a spring tide has fallen three feet three inches, we may know that high water has passed about three hours.

TABLE XI.

Giving the height of the tide above low water for every half hour before or after high water, the total range being taken as equal to 1.

Time before or after high water.	NEW YORK.		OLD POINT COMFORT.	
	Spring tide.	Neap tide.	Spring tide.	Neap tide.
h. m.				
0 0	1.00	1.00	1.00	1.00
0 30	0.98	0.98	0.98	0.98
1 0	0.94	0.93	0.95	0.94
1 30	0.89	0.86	0.88	0.87
2 0	0.80	0.72	0.80	0.78
2 30	0.72	0.59	0.70	0.68
3 0	0.60	0.45	0.59	0.57
3 30	0.49	0.31	0.49	0.44
4 0	0.39	0.19	0.37	0.34
4 30	0.28	0.10	0.26	0.22
5 0	0.18	0.02	0.17	0.13
5 30	0.09	0.00	0.08	0.05
6 0	0.05	------------	0.03	0.01
6 30	0.00	------------	0.00	0.00

APPENDIX No. 18.

Report made to the Superintendent, showing the least water in channel entrances to certain harbors, rivers, and anchorages, on the coasts of the United States; prepared by Lieut. W. D. Whiting, and revised by Lieutenants Commanding J. J. Almy and T. A. Craven, U. S. N., assistants in the Coast Survey. Tidal data by Assistant L. F. Pourtales, in charge of Tidal Division.

Places.	Limits between which depths are given.	LEAST WATER IN CHANNEL WAY.				Authorities.
		Mean.		Spring tides.		(From Coast Survey data when not otherwise stated.)
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Portland, Maine	From Cape Elizabeth to Portland light	45	53.8	44.5	54.4	
	*From Portland light to breakwater	36	44.8	35.5	45.4	
	From breakwater to end of Munjoy Point	30	38.8	29.5	39.4	1850, '53, and '54.
	From breakwater to anchorage	16	24.8	15.5	25.4	
	Channel way off town and wharves	27	35.8	26.5	36.4	
	From Munjoy to railroad bridge	19.5	28.3	19	28.9	
Portsmouth, N. H	From Whale's Back to Fort Constitution	42	50.6	41.4	51.3	
	From Fort Constitution to the Narrows	51	59.6	50.4	60.3	1851.
	From the Narrows to the city	45	53.6	44.4	54.3	
	Off the wharves	63	71.6	62.4	72.3	
Salem, Mass	Northern ship channel, between Baker's and Misery islands	52	61.2	51.3	61.9	
	Southern ship channel, passing Half-way Rock, Gooseberry and Eagle islands, to the northward, Cat island and Coney island to the southward	28	37.2	27.3	37.9	1850 and '51.

* The depth in channel way varies between 6, and $8\frac{1}{2}$ fathoms.

APPENDIX No. 18—Continued.

Place.	Limits between which depths are given.	Least water in channel way. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Salem, Mass.	Inside of Salem Neck	19	28. 2	18. 3	28. 9	1850 and '51.
Boston, Mass.	Main ship channel, between Lovel's and Gallop's island	28. 5	38. 5	27. 8	39. 1	
	Broad sound, south channel	19. 5	29. 5	18. 8	30. 1	
	President's Roads, anchorage	31. 5	41. 5	30. 8	42. 1	1846, '47, '48, and '53.
	Main ship channel, between Governor's island and Castle island	18	28	17. 3	28. 6	
Narragansett bay to Prudence island.	Entering with Boston Neck on port hand. Beavertail and Dutch island lights on starboard hand, passing between Canonicut Point and Hope island	25	28. 9	24. 6	29. 2	Com. Wadsworth, 1832.
	Entering with Beavertail light on the port, and Castle Hill on starboard hand, up to Goat island	60	63. 9	59. 6	64. 2	
	Anchorage, southward and westward of Goat island	33	36. 9	32. 6	37. 2	
	Abreast of wharves, inside of Goat island	21	24. 9	20. 6	25. 2	
	From Newport harbor, inside of Gull Rocks, to Prudence island	31	34. 9	30. 6	35. 2	1848.
	To Mount Hope bay	42	45. 9	41. 6	46. 2	
	To Mount Hope bay, with Cormorant Rock, Sachuest Point on port, and Saughkonnet Point on starboard hand	20	23. 9	19. 6	24. 2	
New York	Gedney's channel	24	28. 8	23. 6	29. 1	
	North channel	22	26. 8	21. 6	27. 1	
	South channel	22. 5	27. 3	22. 1	27. 6	
	Main ship channel, passing Sandy Hook to S.W. Spit buoy	31	35. 8	30. 6	36. 1	From 1835 to 1853, inclusive.
	Main ship channel, after passing S.W. Spit buoy on N.E. course, one mile up the bay for New York	22	26. 8	21. 6	27. 1	
Delaware bay	*Main ship channel, passing Delaware breakwater	61	64. 5	60. 4	64. 9	
	Off Brandywine light-house	43	46. 5	42. 4	46. 9	
	Main ship channel, passing False Liston's tree, to abreast of Bombay Hook light	27. 5	33. 4	27. 3	34. 2	
	Blake's channel, along Flogger shoal	13. 5	19. 4	13. 3	20. 2	
	Blake's channel, passing Mahon river light	13. 5	19. 4	13. 3	20. 2	
	Main ship channel, approaching Liston's Point	20	25. 9	19. 8	26. 7	
Delaware river	Main ship channel, up to Reedy island	20	26	19. 6	26. 3	From 1840 to 1844, inclusive.
	Main ship channel, opposite Reedy island light-house	24. 5	30. 5	24. 1	30. 8	
	Opposite Delaware city	30	36	29. 6	36. 3	
	Up to Christiana Creek light	20. 5	27	20. 3	27. 2	
	Up to Marcus Hook	20. 5	27	20. 3	27. 2	
	Opposite Chester	24. 5	30. 7	24. 4	31. 2	
	Bar off Hog island	18. 5	24. 7	18. 4	25. 2	
	Between Greenwich Point and Gloucester Point	31. 5	37. 5	31. 4	38. 2	
	From Greenwich Point up to Philadelphia	21. 5	27. 5	21. 4	28. 2	

* Soundings varying between 10 and 15 fathoms.

APPENDIX No. 18—Continued.

Places.	Limits between which depths are given.	Least water in channel way. Mean.		Spring tides.		Authorities.
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Chesapeake bay	From capes at entrance to Hampton Roads	30	32.5	29.8	32.8	
	Anchorage in Hampton Roads	59	61.5	58.8	61.8	
	From Hampton Roads to Sewall's Point	25	27.5	24.8	27.8	1852, '53, and '54.
	South of Sewall's Point, (one mile and a half.)	21	23.5	20.8	23.8	
	Up to Norfolk	23	25.5	22.8	25.8	
Elizabeth river, Va.	Between Norfolk and navy yard	25.5	28	25.3	28.3	
Hatteras inlet, N. C.	Over northern bar	12.5	14.5	12.4	14.6	1850.
	Over southern bar	12.5	14.5	12.4	14.6	1850.
	Over northern bar	12	14	11.9	14.1	1852.
	Over southern bar	14	16	13.9	16.1	1852.
Ocracoke inlet	Over bar	10.7	13.1	10.5	13.3	1852.
Beaufort, N. C.	Entrance to channel	15.5	18.3	15.3	18.6	1854.
Cape Fear	New inlet bar	7	11.5	6.5	12	1851, '52, and '53.
	*Main ship channel, Cape Fear river	8	12.5	7.5	13	
	Western rip	8	12.5	7.5	13	1856.
	Western bar	10	14.5	9.5	15	
Georgetown, S. C.	Entrance to Winyah bay, East and Southeast Pass	7	10.8	6.7	11.3	
	Anchorage inside of North island	27	30.8	26.7	31.3	1851, '52, and '53.
	Up to Georgetown	9	12.6	8.7	13.1	
Charleston, S. C.	Main bar	11	16.3	10.8	17.1	
	North channel	10	15.3	9.8	16.1	1850.
	Maffitt's channel	7	12.3	6.8	13.1	
	Maffitt's channel	11.5	16.8	11.3	17.6	1855.
North Edisto	Over bar at entrance	13	18.8	12.5	19.4	1856.
Port Royal	Channel up to Northeast branch	19	26	18.5	26.5	Des Barres, 1777.
	South channel	19	26	18.5	26.5	1855.
	Southeast channel	20	27	19.5	27.5	1856.
	East channel	17	24	16.5	24.5	1855.
Tybee entrance	Bar near Tybee island	19	26	18.4	26.5	1851 and '52.
	Tybee Roads	31	38	30.4	38.5	
Savannah	Channel up to city, (Wrecks and Garden Bank.)	11	17.5	10.6	18.2	Captain Gilmer, U S. Engineers —1856.
St. Simon's	Over bar at entrance	17	23.1	16.5	23.8	
	Entrance to sound	38	44.1	37.5	44.8	1855 and '56.
	Turtle river, up to Blythe island	21	27.1	20.5	27.8	
Doboy bar and inlet	Entrance over bar	15.5	22.1	14.7	22.5	1855.
	Anchorage in sound	24	30.6	23.2	31	
St. Mary's river	On bar	14	19.9	13.5	20.2	Captain Mackay, U. S. Top. Engrs. and Coast Survey.—1856.
	Channel up to St. Mary's	19	24.9	18.5	25.2	
St. John's river, Fla.	Over bar at entrance	7	11.6	6.5	12	1855.
	Channel passing up towards Jacksonville	23	25.1	22.5	25.5	
Key West	Main ship channel to middle buoy on shoals	27	28.4	26.7	29	
	From shoals to anchorage	30	31.4	29.7	32	
	East channel, entering	30	31.4	29.7	32	
	On course N.N.W. ½ W., (light on O'Hara's observatory,) and passing between shoals	28	29.4	27.7	30	
	From 14 feet shoals to anchorage	30	31.4	29.7	32	1850 and '51.
	At anchorage	27	28.4	26.7	29	
	Rock Key channel	20	21.4	19.7	22	
	Sand Key channel	27	28.4	26.7	29	
	West channel	30	31.4	29.7	32	
	Northwest channel, up to abreast N.W. light	15	16.4	14.7	17	

* Subject to frequent changes.

APPENDIX No. 18—Continued.

Places.	Limits between which depths are given.	LEAST WATER IN CHANNEL WAY. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Key West	Ove[illegible]thwest channel bar	11	12.4	10.7	13	1850 and '51.
Tortugas	Northwest channel	45	46.2	44.8	46.4	
	Southwest channel	54	55.2	53.8	55.4	
	East channel	45	46.2	44.8	46.4	
	Anchorage at Garden key	30	31.2	29.8	31.4	1854.
Cedar keys	Channel	10	12.5	9.7	12.6	1854.
St. Mark's	Over bar	11	13.2	10.6	13.5	1852.
	Channel at middle buoy	12	14.2	11.6	14.5	
	Up to Fort St. Mark's	7	9.2	6.6	9.5	
Apalachicola†	Channel	12.5	13.6	12.2	14	Col. Kearney, U. S. topographical engineers. 1822.
Pensacola†	Over bar, channel	21.5	22.5	22.2	22.7	
	From bar to navy yard	28	29	27.7	29.2	
	From navy yard to city	31	32	30.7	32.2	
	*Off wharf at Pensacola	20	21	19.7	21.2	
Mobile bay and river†	Over outer bar	21	22	20.7	22.2	From 1847 to '52, inclusive.
	Main ship channel to Fort Morgan	36	37	35.7	37.2	
	To the upper fleet	12	13	11.7	13.2	
Ship Island harbor†	Channel	19	20.3	18.7	20.6	1848.
	Northwest channel	19.5	20.8	19.2	21.1	
	Anchorage, Man-of-war harbor	18	19.3	17.7	19.6	
Cat Island harbor†	Ship channel	16	17.3	15.7	17.6	1848.
	South Pass	14	15.3	13.7	15.6	
	Shell Bank channel	15.2	16.5	14.9	16.8	
Mississippi delta†	Pass à Loutre, north channel	9.5	10.6	9.3	10.7	1851.
	South channel	12	13.1	11.8	13.2	
Northeast Pass†	Over bar, north entrance	9.5	10.6	9.3	10.7	1851.
	Over bar, south entrance	9	10.1	8.8	10.2	1851.
Southeast Pass†	Entering	10	11.1	9.8	11.2	1851.
South Pass†	Channel	8	9.1	7.8	9.2	1852.
Southwest Pass†	Channel	13	14.1	12.8	14.2	1852.
Barataria bay†	Over bar, outside of Grand Pass	7.5	8.7	7.2	8.9	1852.
	Grand passage, to Independence island	15	16.2	14.7	16.4	
Dernière or Last island†	Channel inside and north of Ship Island shoal light-ship	27	28.4	26.7	28.8	1853.
	Channel north of Ship shoal, one mile from beach of Dernière island	14	15.4	13.7	15.8	
Sabine Pass†	Across the bar	7.5	9	7.2	9.3	1853.
Galveston bay†	Galveston bay	12	13.1	11.7	13.3	1853.
Aransas Pass†	Aransas Pass	9	10.1	8.7	10.5	1853.
Rio Grande†	Rio Grande	4	4.9	3.8	5	1853.

* Varying between 20 and 24 feet water.

† The highest tides occur at the moon's greatest declination, and are applied in the column headed "Spring tides."

APPENDIX No. 18—Continued.

Places.	Limits between which depths are given.	Least water in channel way. Mean, lowest of day. Low water.	Mean, lowest of day. High water.	Spring tides, lowest of day. Mean. Low water.	Spring tides, lowest of day. Mean. High water.	Spring tides, lowest of day. Moon's greatest declination. Low water.	Spring tides, lowest of day. Moon's greatest declination. High water.	Date.
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
San Diego bay	Entrance	27.4	31.5	26.8	32.1	26.3	31.4	1851.
Monterey harbor	Near shore	30	33.9	29.5	34.2	28.9	33.8	1852.
San Francisco harbor	On the bar	33	37	32.6	37.4	31.9	36.7	} 1855.
	At best wharves	20	24	19.6	24.4	18.9	23.7	
Humboldt bay	Main channel	20	24.7	19.3	25.3	18.7	25.1	1851.
Columbia river	North channel to Baker's bay	24	30.5	23.4	30.9	22.7	30.6	} 1852.
	*Entrance into south channel	19	25.5	18.4	20.9	17.7	25.6	
Shoalwater bay	North channel	22.5	29	21.6	29.5	20.9	29	} 1853.
	South channel	25	31.5	24.1	32	23.4	31.5	
False Dungeness	Harbor anchorage	54	60					1853.
Bellingham bay		60	67					1855.

* Twenty-one feet may be carried in at mean low water, by keeping a little northward and westward, nearer the breakers of the *middle sands*, and, at the turn, hauling up for Cape Disappointment.

APPENDIX No. 19.

REPORTS OF THE CHIEFS OF DIVISIONS TO CAPTAIN H. W. BENHAM, CORPS OF ENGINEERS, ASSISTANT IN CHARGE OF THE OFFICE, SHOWING THE DETAILS OF WORK EXECUTED IN EACH DIVISION.

Report of Assistant Charles A. Schott, in charge of the Computing Division.

COAST SURVEY OFFICE, *October* 1, 1856.

In conformity with the regulations of the Survey, I herewith respectfully submit the annual report on the result of the labors of the several computers for the year ending October 1, 1856.

The charge of the division has continued as heretofore, Assistant J. E. Hilgard acting only for a few weeks, while I was engaged on field duty. During the first half of the year the number of computers was the same as in the year previous, but was afterwards diminished by the transfer of Mr. Toomer to a field party. The force employed proved sufficient, although to one branch of discussions a greater expanse has been given than was at first thought necessary.

The general organization in regard to the distribution of the work remains the same as in former years, the system at present in use having continued to be as efficient as it is economical. The work for the publication of records and results has been assisted, as far as could be done, by this division, and the general directions have been followed as close as circumstances would permit.

The nature and amount of work done will be seen by referring to the following detailed statement of the occupation of each computer:

Besides conducting the operations of the division for nearly the whole of the year, I was engaged on field duty for five weeks, determining the three magnetic elements at 17 stations in Section III; in which operations I was aided by Mr. J. L. Tilghman. Instrumental constants were determined at Washington before taking the field in August, and resumed, in September, after my return. The principal reports and special discussions made by myself are as follows:

A discussion, supplementary to my former paper, on the secular change of magnetic declination on the Atlantic Coast, including the results of last year's magnetic observations; a report on the geodetic connection of Sections III and IV; a paper on the eastwardly tendency of the Gulf Stream; a collection of least square formulæ, as applied to geodesy; a collection of all the magnetic term-day observations of the survey; a discussion of the station error in latitudes, as resulting from a comparison of the astronomical and geodetic latitudes, in Sections I, II, and III; a report on the chronometric longitude of Deer and Hurricane islands; a discussion of the secular variation of the magnetic inclination in the Northeastern States, and a similar discussion for the Western Coast; also, a discussion of the secular change of the declination for the same coast; reports on certain astronomical azimuths in Sections I and III; on the chronometric longitude of Allston, S. C.; and a discussion of the position error of the 24-inch theodolite, with special reference to azimuth observations. The Coast Survey Scientific bibliographical Index was increased by 907 extracts and translations of titles, selected from 364 volumes.

Mr. Eugene Nulty completed the reduction of the latitude of Yard station, Section II, 1854; made a second reduction of the magnetic declination dip and intensity of the sixteen stations occupied last year, in Sections I, II, and III; completed the computation of the azimuth and latitude of Mount Harris, Section I, 1855; reduced the azimuth of Santa Cruz, Section X, 1854; completed the reduction of the East Base azimuth, Section IX, 1853; and the reduction of Mount Ragged azimuth, Section I, 1854. Mr. Nulty also deduced the results of the latitude of Fernandina Station, Section VI, and of Montgomery, Section VIII. Mount Harris (1855) must be considered as a triple station, and Ragged Mount (1854) as a double station, Mr. Nulty determining the astronomical latitude as resulting from each instrument and observer. The above computations generally include the reductions of the corresponding observations for time.

Assistant Theodore W. Werner completed the reduction of Assistant Gilbert's triangulation in Texas, 1855, and of Lieutenant Totten's and Sub-Assistant Rockwell's on Florida keys, 1855. Mr. Werner computed the latitude, longitude, and azimuth of the geodetic stations on Rappahannock river, including triangle side reductions, and made out a least square abstract of horizontal angles at Hill, 1850, and Mount Harris, 1855; solving the normal equations and bringing out final results; reduced the Admiralty Inlet triangulation, Section XI, 1855; recomputed the Canal de Haro and Rosario Strait triangulation, and computed the additional part of 1854. He also established and solved the normal equations of horizontal angles at Ragged Mount, 1854; extended the projection tables for special use for Assistant Hilgard; assisted the trigonometrical operations near New York by computing the L, M, Z, of positions determined by Assistant Blunt; reduced the triangulation near the mouth of York river, Section III, 1855; and nearly completed the second reduction of the astronomical latitude of Humboldt, Section X, 1854, inclusive of the transit observations.

Mr. James Main completed the reduction of the magnetic intensity at the stations occupied in 1855; assisted Mr. Hilgard, by preparing forms, and otherwise, for the publication of results; revised the astronomical azimuths of the stations Agamenticus, Sebattis, Mount Harris, Marriott, Webb, Cape Florida, Sand key, and Breach inlet; computed the azimuth of Causten, Section III; revised the first and second reduction of my magnetic results of 1855, in Sections I, II, and III; made a second computation of the chronometric longitude of Deer and Hurricane islands; a second reduction of the magnetic observations at Mount Harris, Ragged Mount, Camden, Yard, Savannah, Tybee, and Neé-ah bay, and completed the general revision of magnetic results at all the Coast Survey stations. He also revised Professor Locke's and Professor Renwick's magnetic intensities, under Assistant Hilgard's special direction; made good progress in putting some astronomical formulæ in proper shape for the Superintendent's table, and performed some miscellaneous computations.

Mr. G. Rumpf was engaged on the revision of the reduction of triangulations, and inserting the results in the proper registers; principally supplied the information asked for by the office or field parties; and prepared the annual geodetic statistics and tables of geographical positions. He completed the reduction of vertical angles about Casco bay, Section I, 1850–'52–'54, and the abstract of angles of the primary stations near the mouth of Chesapeake bay; computed a second set of rectangular co-ordinates for the mouth of the Rio Grande; computed in part the reduction of some vertical angles in Section I; determined the elevations of stations between San Francisco and Monterey bay, (occupied by Assistant Cutts in 1852–'54–'55;) assisted in the discussion of the position error of the twenty-four inch theodolite; reduced the horizontal angles at Webb, Soper, and Hill stations, 1850; and completed the reduction of the St. Andrew's bay triangulation, begun by Mr. Toomer. Mr. Rumpf also reduced the Romerly Marshes triangulation, and Assistant Farley's triangulation on James river, as far as practicable; computed Sub-Assistant McCorkle's triangulations of St. Mark's and Apalachicola, Section VII; assisted Mr. Hilgard in the reduction of his triangulation, Section VIII; made a second computation of the Deer island azimuth; performed some miscellaneous computations, and instructed, for some time, in office methods, Messrs. Gillis and Hough, temporarily attached to the division.

Mr. John Wiessner reduced the transits observed at Deer and Hurricane islands, and determined the longitude of the same, (1854 and 1855;) assisted Mr. Hilgard in the reduction of his triangulation in Section VIII, 1855; aided in the computation for the secular change of the magnetic declination; prepared some tables for the General Land Office, relative to the Florida keys; made a second reduction of the Currituck Sound triangulation, (joining Sections III and IV;) deduced the chronometric longitude of Allston, S. C., including the transit observations at Charleston; made a reduction of the horizontal angles at Webb and Soper stations (1850) by the method of least squares, with special reference to the publication of results; made the check computation of the latitudes of Cape Disappointment and Point Pinos, and nearly completed the latitude reduction of Ewing harbor. He performed, besides, some miscellaneous calculations.

Mr. J. H. Toomer completed the first reduction of the triangulation of the Rappahannock river, and assisted in the preparation of the list of geographical positions for the report of 1855; computed the geographical positions of Assistant Gilbert's triangulation in Section IX; reduced the triangles joining James and Appomattox rivers, Section III; reduced the triangulation of the Santa Barbara channel, Section X, and computed rectangular co-ordinates for the same; reduced the Ballenas bay (tertiary) triangulation, Section X; made the second reduction of the Chandeleur island triangulation, 1855, Section VIII; and had made satisfactory progress with the reduction of the St. Andrew's triangulation, Section VII, 1854 and 1855, when he was detached from the division for field duty. His services had been very acceptable in the division.

Mr. J. E. Blankenship assisted Mr. Hilgard in the discussion of magnetic declinations and isogonic lines; aided in the preparation of the magnetic term-day observations for publication; and also in the list of geographical positions for the report of 1855. He extended the projection tables under Mr. Hilgard's direction, and assisted me on the computations for the secular change of the magnetic dip. He reduced mean to apparent places of stars, preparatory to the second reduction of the latitudes on the Western Coast, for stations Cape Disappointment and Presidio; and since May last, assisted Mr. Hilgard on the reduction of magnetic data relating to the isogonic, isoclinal, and isodynamical lines.

Mr. John T. Hoover performed the clerical duties of the division with the same attention as in former years, and rendered much assistance in the preparation of copies of mathematical papers for the Superintendent's report of 1855. He has completed a duplicate of my last year's magnetic record; assisted also in the computation of geographical positions near New York; prepared fair copies of various papers containing formulæ, methods, and examples; and constructed some large wall diagrams relating to latitude and magnetic discussions. His services at the magnetic observatory in the Smithsonian grounds are noticed elsewhere.

Mr. Samuel Walker was assigned for temporary duty to the computing division, October 18; and made some comparisons and conversions of measures, assisted in proof-reading, and reduced mean to apparent places of stars, preparatory to the second reduction of the Western Coast latitude, completing for that purpose the stations Point Conception and Point Pinos. He was transferred to Sub-Assistant Mitchell's party on the 12th of December.

Mr. J. L. Tilghman reported on the 23d of October for temporary duty, and had made some progress in the study of office methods when he was assigned to field duty. He rejoined the division June 9, and served in my magnetic party as aid, in August. He assisted also in copying some magnetic papers.

Mr. S. J. Hough reported for temporary duty, June 20, and reduced the observations of Sub-Assistants Rockwell and Sullivan on the Florida reef triangulation, 1855 and 1856. After duplicating the record of this triangulation, he was detached, about the last of July.

The observations on magnetic term-days, from November to May, inclusive, were attended to by Messrs. Hoover, Main, Rumpf, Blankenship, and Wiessner. Additional copying required for field parties was done by R. Freeman. The current computations at the office relative to geodetic, magnetic, and astronomical work have thus been kept up with the field operations, and the magnetic discussions especially have been as far advanced as the observations permitted. All calls on the division have met with prompt attention.

Report of Assistant L. F. Pourtales, in charge of the Tidal Division.

COAST SURVEY OFFICE, *October* 1, 1856.

I submit herewith my report on the occupation of the computers in this division during the past year, being a recapitulation of the reports addressed to you monthly.

Mr. R. S. Avery has made a discussion of the tides of Boston, and deduced from it tables for the prediction of tides. He has also devoted some time to attempts at simplification of the formulæ used, and of the method of solving them.

Mr. J. Kincheloe discussed the daily inequality of the Boston tides. He also made similar computations for San Diego, after having previously revised the reductions of the whole series. He computed the daily inequality for several stations on the Western Coast; decomposed the tides of Fort Steilacoom, Washington Territory; discussed the tides of St. John's river, Florida; and made various other minor computations.

Mr. C. Fendall reduced the series of simultaneous tides observed on the Western Coast in 1855; decomposed their curves of observations, and compared the resulting diurnal and semi-diurnal tides. He made a graphical decomposition of the curve of observation for a whole year at San Francisco, and assisted in the discussion of the results. He also decomposed the observations at several of the stations in the Gulf of Mexico, to be used by the Superintendent in the preparation of a paper on the co-tidal lines of that sea. The diagrams for that paper and various tables relating to it were prepared by Mr. Fendall. Various minor computations and plottings were also made by him in the course of the year.

Mr. J. Downes joined the division in December; and, after having made himself familiar with the ordinary modes of reduction, he computed the theoretical lunitidal intervals of the diurnal tides of San Francisco by Airy's formulæ. He then made computations for the paper on the co-tidal lines of the Gulf of Mexico, prepared by the Superintendent, and read before the American Association for the Advancement of Science. Mr. Downes is now engaged, under Mr. Hilgard's directions, in the preparation of records for publication.

Mr. G. C. Blanchard made the ordinary first and second reductions of the current tidal observations; and also copies of sailing directions for the office. After Mr. Evans' departure for the field, he read off the records of the self-registering tide-gauges, and has continued the usual copying of correspondence, reports, &c., for the division.

Mr. R. E. Evans read off and reduced the tidal observations from self-registering tide-gauges until May 30, when he was detached, and reported to Assistant G. W. Dean for field duty.

Mr. R. T. Bassett was attached to the division from the 6th of November to the 1st of June, and made ordinary first and second reductions—chiefly of Western Coast tides. He prepared tables of transit of the moon, and duplicated some records of observations.

Occasional help was also rendered, chiefly in the way of plottings and graphical decompositions by Messrs. S. Walker and W. G. Williams, attached to Sub-Assistant Mitchell's party.

The meteorological observations made at the permanent stations on the Western Coast were reduced and tabulated by Mr. Thomas.

Report of Lieut. J. C. Tidball, U. S. A., in charge of the Drawing Division.

COAST SURVEY OFFICE, *November* 1, 1856.

Since the date of last report, this division has remained under my charge, in the duties of which I have been assisted by Mr. G. A. Porterfield.

Such changes as have taken place in the organization of the division will appear in the details of this report, and I respectfully refer to the "List of maps and sketches completed or in progress," for the yearly advancement.

The following is a statement of the work executed by draughtsmen:

Assistant W. M. C. Fairfax has been engaged upon the reduction of topography of San Francisco entrance, $\frac{1}{50000}$; Patapsco river, $\frac{1}{60000}$; Cape Cod bay, $\frac{1}{80000}$; the topography and hydrography of Eastern series No. 3, $\frac{1}{80000}$; projections for fine reductions; projections on copper; verifications and examinations.

Assistant M. J. McClery made additions to the Congress map, $\frac{1}{1500000}$; a sketch of Boston harbor, $\frac{1}{200000}$; completed the topography of Biloxi bay, $\frac{1}{40000}$; and has been engaged upon the topography of the general coast-chart, from Cape Ann to Point Judith, $\frac{1}{400000}$; and coast-chart from Portsmouth to Cape Ann, $\frac{1}{80000}$.

Mr. Joseph Welch has continued reducing the topography of Massachusetts bay, $\frac{1}{80000}$; and made additions to the topography of Boston harbor, $\frac{1}{40000}$.

Mr. J. J. Ricketts has completed the reduction of hydrography from the lower sheet of Cape Fear river, $\frac{1}{30000}$; San Francisco entrance, $\frac{1}{50000}$; and has been employed upon the hydrography of Savannah river, $\frac{1}{40000}$; general coast-chart from Cape Ann to Point Judith, $\frac{1}{400000}$; and verifications of hydrographic reductions.

Mr. A. Boschke has been employed upon the maps of New York bay and harbor, for the Commissioners, and on projects. During the greater part of the year he has been detached from the office on that special duty.

Mr. L. D. Williams has been engaged upon the reduction of topography of Plymouth harbor, $\frac{1}{20000}$; additions to the Congress map, $\frac{1}{1500000}$; topography of Chesapeake bay, No. 2, $\frac{1}{80000}$; topography and hydrography of Romerly marshes, $\frac{1}{10000}$; sea-coast of Virginia, $\frac{1}{200000}$; additions to the chart of the Gulf Stream, $\frac{1}{5000000}$; Charleston bar, comparative chart, $\frac{1}{10000}$; additions to Georgetown harbor and Winyah bay, $\frac{1}{40000}$; compilation of the map of Central America, $\frac{1}{2500000}$, for the Committee on Foreign Relations, United States Senate; and on miscellaneous drawings, projections and verifications.

Mr. A. Balbach was on duty in the office from the 8th of February till the 25th of June, when he rejoined the party of Lieut. Comg. Craven. During that time he was employed on the reduction of hydrography of Florida reefs, $\frac{1}{200000}$ and $\frac{1}{80000}$; and on miscellaneous hydrographic work, verifications and examinations.

Mr. A. Lindenkohl completed the topography of Savannah river, $\frac{1}{40000}$; and has drawn maps of magnetic declinations, Nos. 1 and 2, $\frac{1}{5000000}$; isogonic lines, $\frac{1}{15000000}$; additions to the Congress map, $\frac{1}{1500000}$; diagram map of the United States, $\frac{1}{2500000}$; sketch of Port Ludlow, $\frac{1}{20000}$; map of Anacapa and east end of Santa Cruz island, $\frac{1}{30000}$; comparative chart of Hudson river, between Albany and New Baltimore, $\frac{1}{10000}$; verifications; additions to progress sketches; projections on copper; projections for field parties; and projections for the Light-House map, $\frac{1}{600000}$.

Mr. J. R. Key has been employed upon the map of New York bay and harbor, for Commissioners, $\frac{1}{20000}$; Cape Fear river, lower sheet, $\frac{1}{30000}$; coast of Massachusetts, No. 1, $\frac{1}{200000}$; Hudson river, lower sheet, $\frac{1}{60000}$; Annis Squam and Ipswich harbors, $\frac{1}{20000}$; and miscellaneous drawings.

Mr. W. T. Martin has completed the topography of St. Andrew's bay, $\frac{1}{40000}$; sketch of Legaré anchorage, $\frac{1}{20000}$; and has been employed upon the upper sheet of James river, $\frac{1}{40000}$; Rappahannock river, Nos. 3 and 4, $\frac{1}{20000}$; and on progress sketches.

Mr. W. P. Schultz has reduced the lower sheet of St. John's river, $\frac{1}{25000}$; sketch of Port Gamble, $\frac{1}{20000}$; New Dungeness, $\frac{1}{40000}$; and has been employed upon the Light-House map, $\frac{1}{600000}$; shore-line measurements, progress sketches, projections, and miscellaneous work.

Mr. A. E. Hartman joined the office on the 2d of June, and has been engaged upon projects.

Mr. P. Witzel joined the office on the 14th of August, and has been employed upon the Light-House map and progress sketches.

Mr. F. Fairfax has reduced the topography of Cape Fear river, upper sheet, $\frac{1}{30000}$; drawn maps illustrating physical geography of the Western Coast, and has been engaged upon the sheet of Romerly marshes, $\frac{1}{10000}$; and the topography of the two upper sheets of Rappahannock river, $\frac{1}{20000}$.

Mr. W. Fairfax entered the office upon trial on the 22d of October, 1855, and continued until the 1st of January, when he was permanently engaged. He has been employed upon Sandy Hook changes, $\frac{1}{40000}$; Tampa bay, $\frac{1}{120000}$; Romerly marshes, $\frac{1}{10000}$; and shore-line measurements; and has reduced Port Royal entrance and Beaufort river, $\frac{1}{60000}$.

Mr. F. D. Stuart, on contract, has been engaged on the hydrography of Mississippi sound, No. 2, $\frac{1}{80000}$; Muskeget channel, $\frac{1}{50000}$; and has completed the hydrography of St. Andrew's bay, $\frac{1}{40000}$, and Cape Fear river, upper sheet, $\frac{1}{30000}$.

Mr. F. Stout was temporarily employed in the division, from the 8th of December until the 1st of July, during which time he was engaged upon Albemarle sound, $\frac{1}{200000}$; Maffitt's channel, $\frac{1}{5000}$; Gulf of Mexico, $\frac{1}{2400000}$; Galveston bay, $\frac{1}{200000}$; Shoalwater bay, $\frac{1}{80000}$; and Bellingham bay, $\frac{1}{40000}$.

Mr. A. Schoepf, on contract, has reduced the seacoast of Alabama and Mississippi, $\frac{1}{200000}$; seacoast of Virginia, south of Cape Henry, $\frac{1}{200000}$; and made additions to Galveston bay, $\frac{1}{200000}$.

Mr. L. Daser, on contract, has made projections for field parties, and verified and corrected seacoast of Alabama and Mississippi, $\frac{1}{200000}$.

Mr. R. L. Eastman was temporarily employed in the office, from the 17th of December until the 10th of May, principally upon progress sketches.

Artificer J. A. Campbell has been continued upon tracings, and in charge of the miscellaneous maps.

Messrs. B. Hooe, H. McCormick, and S. B. Linton, have been employed on tracings.

The following papers prepared in this division for the Superintendent's report of 1856, are respectfully submitted herewith:

A. List of maps and sketches completed, or in progress, during the year ending November 1, 1856.

B. List of information furnished by the Coast Survey, under authority of the Treasury Department. (Appendix No. 5.)

C. List of capes, headlands, islands, harbors, and anchorages surveyed on the Western Coast. (Appendix No. 6.)

List of maps and sketches completed, or in progress, during the year ending November 1, 1856, *arranged in order of sections.*

Name.	Scale.	Description.	Remarks.
SECTION I.—*Coast of Maine, New Hampshire, Massachusetts, and Rhode Island.*			
Progress sketch A	1–600,000		Completed.
Progress sketch A, *bis*	1–400,000		Do.
Portland harbor, Maine	1–10,000	Chart showing city wharf-line	Do.
Seacoast from Portsmouth to Cape Ann, New Hampshire and Massachusetts	1–80,000	Finished map	In progress.
Annis Squam and Ipswich harbors, Massachusetts	1–20,000	do	Do.
General coast chart from Cape Ann to Point Judith, Massachusetts and Rhode Island	1–400,000	Finished chart	Do.
Massachusetts bay	1–80,000	Finished map	Do.
Boston harbor, (additions,) Massachusetts	1–40,000	do	Completed.
Do Massachusetts	1–200,000	Sketch	Do.
Seacoast of Massachusetts, No. 1, including Cape Cod and Buzzard's bays	1–200,000	Preliminary chart	In progress.
Plymouth harbor, Massachusetts	1–20,000	Finished map	Completed.
Cape Cod bay, Massachusetts	1–80,000	do	In progress.
Eastern series, No. 3, Massachusetts	1–80,000	do	Do.
Bass River harbor, Massachusetts	1–40,000	do	Completed.
Muskeget channel, (additions,) Massachusetts	1–60,000	Finished chart	Do.
SECTION II.—*Coast of Connecticut, New York, New Jersey, Pennsylvania, and Delaware—north of Cape Henlopen.*			
Progress sketch B	1–800,000		Completed.
New York bay and harbor	1–10,000	Comparative chart, 1836 to 1854, for Commissioners on Harbor Encroachments.	Do.
Do do	1–20,000	Finished map for same	Do.
Sandy Hook, New Jersey	1–40,000	Sketch showing changes, 1779 to 1855.	Do.
Hudson river, from entrance to Sing Sing, N. York	1–60,000	Finished map	In progress.
Hudson river, between Albany and New Baltimore, New York	1–10,000	Comparat'e chart, 1843 to '53	Completed.
SECTION III.—*Coast of Delaware, south of Cape Henlopen, Maryland, and Virginia—north of Cape Henry.*			
Progress sketch C	1–400,000		Completed.
Patapsco river, (additions,) Maryland	1–60,000	Finished map	Do.
Chesapeake bay, No. 2, Maryland	1–80,000	do	In progress.
Rappahannock river, from Fredericksburg to near Moss' Neck, Virginia	1–20,000	do	Do.
Rappahannock river, from Moss' Neck to Port Royal, Virginia	1–20,000	do	Do.
Rappahannock river, from near Port Royal to Saunders' wharf, Virginia	1–20,000	do	Do.
Rappahannock river, from Saunders' wharf to Occupation creek, Virginia	1–20,000	do	Do.
James river, from Richmond to City Point, Virginia	1–40,000	do	Do.
SECTION IV.—*Coast of Virginia, south of Cape Henry, and North Carolina—north of Cape Fear.*			
Progress of sketch D	1–400,000		Completed.
Seacoast of Virginia, south of Cape Henry	1–200,000	Preliminary chart	Do.
Albemarle sound, North Carolina	1–200,000	do	Do.
Cape Fear river, from entrance to Federal Point, N. C.	1–30,000	Finished map	Do.
Cape Fear river, from near Federal Point to Wilmington, N. C.	1–30,000	do	Do.
Gulf Stream	1–5,000,000	Chart	Do.
SECTION V.—*Coast of North Carolina—south of Cape Fear, South Carolina, and Georgia.*			
Progress sketch E	1–400,000		Completed.
Georgetown harbor and Winyah bay, (additions,) S. C.	1–40,000	Preliminary chart	Do.

List of maps and sketches, &c.—Continued.

Name.	Scale.	Description.	Remarks.
SECTION V—Continued.			
Maffitt's channel, Charleston harbor, S. C	1-5, 000	Comparat'e chart, 1852 to '56	Completed.
Charleston bar, S. C	1-10, 000	do. 1850 to '55	Do.
Seacoast of South Carolina, from Charleston to Tybee light	1-200, 000	Preliminary chart	In progress.
Port Royal entrance and Beaufort river, S. C	1-60, 000	Sketch	Completed.
Savannah river to head of Argyle island, Ga	1-40, 000	Finished map	Do.
Romerly marshes, Georgia	1-10, 000	Sketch	Do.
SECTION VI.—*Coast of Florida, from St. Mary's river to St. Joseph's bay, including Florida reefs and keys.*			
Progress sketch F	1-1, 200, 000		Completed.
Progress sketch F, No. 2, (Florida reefs, and Key Biscayne and Cape Sable bases)	1-400, 000		Do.
St. John's river, from entrance to Brown's creek, Florida	1-25, 000	Finished map	Do.
Florida reefs, from Cape Florida to the Tortugas islands, inclusive	1-200, 000	Preliminary chart	In progress.
Florida reefs, from Key Biscayne to Carysfort reef light	1-80, 000	Finished chart	Do.
Legaré anchorage, Florida	1-20, 000	Sketch	Completed.
Tampa bay, Florida	1-120, 000	do	Do.
SECTION VII.—*Coast of Florida—west of St. Joseph's bay, and Alabama—east of Mobile bay.*			
Progress sketch G	1-600, 000		Completed.
Cedar keys, (additions,) Florida	1-50, 000	Finished chart	Do.
St. Andrew's bay, Florida	1-40, 000	Finished map	Do.
SECTION VIII.—*Coast of Alabama—west of Mobile bay, Mississippi, and Louisiana—east of Vermilion bay.*			
Progress sketch H	1-600, 000		Do.
Gulf of Mexico from Key West to mouth of Rio Grande	1-2, 400, 000	Sketch for profiles of deep-sea soundings	Do.
Do do do	1-10, 000, 000	Sketch for co-tidal lines	Do.
Seacoast of Alabama and Mississippi	1-200, 000	Preliminary chart	Do.
Mississippi sound from Round island to Grand island, Miss	1-80, 000	Finished map	In progress.
Biloxi bay, Miss	1-40, 000	do	Completed.
Mississippi delta, La	1-200, 000	Reconnaissance	Do.
SECTION IX.—*Coast of Louisiana—west of Vermilion bay and coast of Texas.*			
Progress sketch I	1-600, 000		Do.
Galveston bay, (additions,) Texas	1-200, 000	Preliminary chart	Do.
Seacoast of Texas from Galveston southward	1-200, 000	do	In progress.
SECTIONS X AND XI.—*Coast of California and of Oregon and Washington Territories.*			
Progress sketches J and K	1-600, 000		Completed.
Anacapa and part of Santa Cruz island, Cal	1-30, 000	Preliminary chart	Do.
San Francisco entrance, Cal	1-50, 000	Finished map	Do.
Shoalwater bay, (extension,) Washington Territory	1-80, 000	Sketch	Do.
New Dungeness harbor, Washington Territory	1-40, 000	do	Do.
Port Ludlow, Washington Territory	1-20, 000	do	Do.
Port Gamble, Washington Territory	1-20, 000	do	Do.
Olympia harbor, Washington Territory	1-20, 000	do	Do.
Steilacoom harbor, Washington Territory	1-30, 000	do	Do.
Blakely harbor, Washington Territory	1-10, 000	do	Do.
Bellingham bay, Washington Territory	1-40, 000	do	Do.
Light-house map	1-600, 000		In progress.
Map of Central America	1-2, 500, 000	Map for U. S. Senate Committee on Foreign Relations.	Completed.
Map of magnetic declinations, No. 1	1-5, 000, 000		Do.
Do do No. 2	1-5, 000, 000		Do.

List of maps and sketches, &c.—Continued.

Name.	Scale.	Description.	Remarks.
SECTIONS X and XI—Continued.			
Map of magnetic declinations	1-15,000,000		Completed.
Diagram map of United States	1-2,500,000		Do.
Diagrams of magnetic declinations			Do.
Sketch of United States for magnetic lines	1-20,000,000		Do.
Boutelle's apparatus for measuring preliminary bases			Do.
Boutelle's scaffold for stations and Farley's signal			Do.
Map of Point Reyes and vicinity, Cal		To accompany a report on physical geography and geology	Do.
Map of the vicinity of the Golden Gate, San Francisco bay, Cal		do	Do.
Map of the vicinity of Monterey bay, Cal		do	Do.
Map of the country between San Diego and the Colorado river, Cal		do	Do.
Deep-sea sounding apparatus		Diagram	Do.
Battery cups for voltaic experiment		do	Do.
Diagrams showing effect of wind on height of water in Albemarle sound			Do.
Diagrams of secular variation of magnetic dip and intensity		Made in computing division	Do.
Diagrams of cotidal lines, Gulf of Mexico			Do.
Type curves, (tides, Gulf of Mexico)		Made in tidal division	Do.
Wind curves, Cat island			Do.
Wind curves, Gulf of Mexico			Do.

Report of Lieutenant Rufus Saxton, 4th artillery, in charge of the Engraving Division.

COAST SURVEY OFFICE,
Washington, D. C., November 1, 1856.

From the date of the last annual report, this division continued under the able direction of Lieutenant J. C. Clark, 4th artillery, until June 1, 1856, when he was relieved from duty in the office, and I was placed in charge, and so continued until the 25th of July. From that time until the 3d of September, during my illness, the duties of the division devolved upon Mr. Edward Wharton, and since the last mentioned date, the division has remained under my charge.

I have been assisted in my duties by Mr. Wharton, whose valuable services I take this opportunity to acknowledge.

The engraving of several important finished charts has been completed during the past year, viz: Gloucester harbor, Boston harbor, Bass River harbor, and Mobile bay.

The northern sheet of Alden's reconnaissance, which partakes of the character of a finished chart, has also been completed.

The important first class charts of Plymouth harbor, Muskeget channel, Monomoy shoals, Eastern series, No. 1, Albemarle sound, No. 2, Beaufort harbor, N. C., and San Francisco entrance, have been well advanced, and will be completed during the ensuing year.

Considerable progress has been made with the engraving of the first class charts of Portland harbor, Eastern series, No. 2, south side Long Island, Nos. 2 and 3, and Chesapeake bay, Nos. 1 and 2.

The following preliminary charts and sketches have been wholly engraved during the year, viz: Portland harbor, Commissioners' line; Boston bay; Stellwagen's bank, 2d edition; Hudson river (lower sheet;) James river, Virginia, (upper sheet;) Cape Fear river, No. 1; Gulf Stream explorations, 1855; diagram showing the effect of the wind in raising or depressing the water in Albemarle sound; Romerly marshes; Savannah river; Legaré anchorage; Tampa bay; St. Andrew's bay; Biloxi bay; deep-sea soundings Gulf of Mexico; Anacapa island; geological maps of San Diego, Monterey, San Francisco, and Point Reyes;

cotidal lines of the Pacific coast; lines of equal magnetic declination on the coast of the United States; earthquake waves, Western Coast; Boutelle's scaffold for stations and Farley's signal; Boutelle's apparatus for measuring preliminary bases; Sands' gas-pipe tripod; Sands' specimen box for deep-sea soundings and revolving heliotrope.

The following plates previously commenced have been completed during the year, viz: Annis Squam and Ipswich harbors; seacoast, Virginia, No. 2; Delaware and Chesapeake bays; Albemarle sound; Winyah bay and Georgetown harbor; Maffitt's channel (sections;) beacons on Florida reefs; Cedar keys; Galveston bay and South Farallon island.

The engraving of the following charts, &c., has been commenced during the year, and is now in progress, viz: Eastern series, No. 2; Rappahannock river, Nos. 3 and 4; Cape Fear river, No. 2; lines of equal magnetic declination on the Atlantic coast; Port Royal entrance; Mississippi sound, No. 2; cotidal lines Gulf of Mexico; Port Ludlow; Bellingham bay; Steilacoom harbor; Port Gamble and lines of equal magnetic declination Pacific Coast.

Additional charts and additions to those previously published, showing the progress of the survey in the different sections, have been engraved.

Engravers Messrs. G. McCoy, F. Dankworth, A. Rollé, J. V. N. Throop, G. B. Metzeroth, A. Maedel, J. C. Kondrup, A. Petersen, and J. J. Knight, have been employed during the entire year on views, topography, and hydrography.

Apprentices S. W. Bradley, R. F. Bartle, F. W. Benner, and W. A. Thompson have been employed the entire year upon preliminary charts, sketches, miscellaneous work, and in practice.

Engravers Messrs. A. Blondeau, A. Sengteller, H. S. Barnard, R. T. Knight, W. Langran, and W. Ogilvie have been employed for a portion of the year on topography and hydrography; and Apprentice Rose upon preliminary charts, progress sketches, and in practice.

I respectfully submit the following general statement of the work executed by the different engravers, viz: Mr. McCoy (chief engraver) has retouched the views on the plates of Long Island sound No. 1, and of Alden's reconnaissance, Western Coast, northern sheet, and has engraved a portion of the topography upon Eastern series, Nos. 1 and 2; Chesapeake bay, No. 2; and outlines of San Francisco entrance.

Mr. Dankworth has engraved a portion of the topography of Mobile bay, a portion of the topography and outlines of Chesapeake bay Nos. 1 and 2, and sanding on Mobile bay and Beaufort harbor, N. C.

Mr. J. Knight has completed the title, sailing directions, and general lettering of Boston harbor, Charleston harbor, a portion of Mobile bay, and a part of the general lettering of south side Long Island, Nos. 2 and 3, San Francisco bay entrance, and other lettering and miscellaneous work, upon important charts.

Mr. Rollé has completed the topography of Boston harbor, and engraved a portion of the outlines and topography of south side Long Island, Nos. 2 and 3, and additional outlines and topography on Patapsco river, and retouched the topography on Mobile bay.

Mr. Blondeau was employed for a time after he joined the division upon practice plates, in order to acquire the style of engraving which has been adopted in this office. He has also engraved the outlines and topography of Anacapa island, and a portion of the topography on the entrance to San Francisco harbor.

Mr. Sengteller has also been employed for a portion of his time upon practice plates, for the same reason as in the case of Mr. Blondeau. He has engraved the outlines and topography of Port Ludlow, and all the outlines and a portion of the topography of Plymouth harbor.

Mr. Metzeroth has engraved the sanding and topography of Gloucester harbor; retouched the views on Long Island sound, No. 2; engraved a portion of the sand on Albemarle sound, No. 2; the outlines of the city of Savannah, on Savannah river; the topography on Beaufort harbor, N. C.; the views on South Farallon island, the shading of Sands' specimen box for deep-sea soundings, and other miscellaneous work.

Mr. Throop has engraved the title, notes, soundings, and general lettering of Hudson river;

soundings, notes, sailing directions, and general lettering of Chesapeake bay, $\frac{1}{400000}$; notes and sailing directions of Mobile bay; soundings, sailing directions, title, and notes of Alden's reconnaissance Western Coast; titles of Winyah bay and Georgetown harbor; Biloxi bay, and other miscellaneous work.

Mr. Maedel has engraved the outlines and a portion of the sand on Annis Squam and Ipswich harbors; additional topography on Muskeget channel and Savannah river; a portion of the topography of Albemarle sound, No. 2; and the outlines and topography on Cape Fear river.

Mr. Barnard has engraved a small portion of the sanding on Muskeget channel; and also a portion of the sand on south side Long Island, No. 2; seacoast of Virginia, No. 2; James river, Va., and Chesapeake bay, $\frac{1}{400000}$.

Mr. Kondrup has engraved the entire sketch of Boston bay, the outlines of Delaware and Chesapeake bays, and Albemarle sound, the soundings of St. Andrew's bay and the soundings, title, and notes of Savannah river.

Mr. R. T. Knight has engraved the outlines, soundings, and sand of Biloxi bay; soundings, title, and notes of Legaré anchorage; title, notes, and general lettering of Tampa bay; general lettering of geological map of San Diego; lines of equal magnetic declination, Atlantic Coast; and title and general lettering of the lines of equal magnetic declination.

Mr. Langran has engraved the title and general lettering of James river; the soundings on Port Ludlow, Steilacoom harbor, and Mississippi sound, No. 2.

Mr. Ogilvie has engraved the title, notes, soundings and general lettering of Portland harbor, Commissioners' line; additional soundings on Muskeget channel and Rappahannock river, No. 3; title and notes of Romerly marshes; title, notes, and general lettering of Gulf Stream explorations, 1855; and general lettering, on lines of equal magnetic declination Pacific coast.

Mr. Petersen has engraved soundings, title, and general lettering of Annis Squam and Ipswich harbors; additional soundings and notes on Winyah bay and Georgetown harbor; soundings and general lettering of seacoast of Virginia, No. 2; title and notes on beacons of Florida reefs; additional soundings, sailing directions, and general lettering on Cedar keys; and title and general lettering of South Farallon island.

Mr. J. J. Knight has engraved the outlines and a small portion of the topography of Bass River harbor; all the sanding, topography, and general lettering of St. Andrew's bay; soundings of Romerly marshes; all the general lettering of geological map of Point Reyes; sanding of beacons on Florida reefs; general lettering of diagram to illustrate secular variation in magnetic declination; Sands' gas-pipe tripod, and Boutelle's apparatus for measuring preliminary bases.

Apprentice Bradley has engraved additional soundings on Stellwagen's Bank; all the topography on Cedar Keys; sailing directions on Galveston bay; general lettering and title of deep-sea soundings of Gulf of Mexico; general lettering on the diagram to show the effect of the wind in elevating and depressing the water in Albemarle sound; general lettering and title of geological maps of San Francisco and Monterey, and other miscellaneous work.

Apprentice Bartle has engraved the marsh and shore-line of seacoast of Virginia, No. 2; all the topography of Romerly marshes and Tampa bay; sanding and topography of Bellingham bay; the shading of Boutelle's scaffold for stations, and other miscellaneous work.

Apprentice Benner has engraved the outlines of Portland harbor, Commissioners' line, shore-lines and profiles of deep-sea soundings Gulf of Mexico; shore-line of Gulf Stream explorations of 1855; James river, Va.; sections of Maffitt's channel; outlines and signs on geological map of Point Reyes; outlines and topography of Steilacoom harbor, and other miscellaneous work.

Apprentices Thompson and Rose have been employed principally upon miscellaneous work, as diagrams, borders, curves, progress sketches, &c., when not engaged upon practice plates.

Apprentice Rose has engraved the sanding and topography of Port Gamble.

I respectfully call attention to the accompanying list of maps and charts engraved, preliminary charts and sketches engraved, and maps and charts engraving.

1856

List of Coast Survey maps, preliminary charts, and sketches engraved—geographically arranged.

1. List of Maps and Charts engraved.

No. 1.	Richmond's Island, Maine	$\frac{1}{20000}$
2.	Newburyport harbor, Massachusetts	$\frac{1}{20000}$
3.	Gloucester harbor...........do	$\frac{1}{20000}$
4.	Salem harbor...........do	$\frac{1}{25000}$
5.	Boston harbor...........do	$\frac{1}{40000}$
6.	Bass river...........do	$\frac{1}{40000}$
7.	Wellfleet harbor...........do	$\frac{1}{50000}$
8.	Nantucket harbor...........do	$\frac{1}{20000}$
9.	Hyannis harbor...........do	$\frac{1}{30000}$
10.	Harbor of Edgartown...........do	$\frac{1}{20000}$
11.	Harbors of Holmes' Hole and Tarpaulin cove, Massachusetts	$\frac{1}{20000}$
12.	Harbor of New Bedford, Massachusetts	$\frac{1}{40000}$
13.	General chart of coast from Gay Head to Cape Henlopen	$\frac{1}{400000}$
14.	Fisher's Island sound, Connecticut	$\frac{1}{40000}$
15.	Harbor of New London......do	$\frac{1}{20000}$
16.	Mouth of Connecticut river, do.	$\frac{1}{20000}$
17.	Harbor of New Haven—new edition, 1852	$\frac{1}{30000}$
18.	Harbors of Black Rock and Bridgeport, Connecticut—new edition, 1852	$\frac{1}{20000}$
19.	Harbors of Sheffield and Cawkin's Island, Conn.—new edition, 1852	$\frac{1}{20000}$
20.	Huntington bay, New York	$\frac{1}{30000}$
21.	Oyster bay or Syosset harbor, New York	$\frac{1}{30000}$
22.	Harbors of Captain's Islands, East and West, New York	$\frac{1}{20000}$
23.	Hart and City islands, and Sachem's Head harbor, New York	$\frac{1}{10000}$, $\frac{1}{20000}$
24.	Hell Gate, New York	$\frac{1}{5000}$
25.	Long Island sound—east	$\frac{1}{80000}$
26.	Do........do.....middle	$\frac{1}{80000}$
27.	Do........do.....west	$\frac{1}{80000}$
28.	New York bay and harbor and the environs, New York—sheet No. 1	$\frac{1}{30000}$
29.	Do..........do..........do..........do..........do. No. 2	$\frac{1}{30000}$
30.	Do..........do..........do..........do..........do. No. 3	$\frac{1}{30000}$
31.	Do..........do..........do..........do..........do. No. 4	$\frac{1}{30000}$
32.	Do..........do..........do..........do..........do. No. 5	$\frac{1}{30000}$
33.	Do..........do..........do..........do..........do. No. 6	$\frac{1}{30000}$
34.	Do..........do..........do..........do..........do.	$\frac{1}{80000}$
35.	Western part of south coast of Long Island, New York	$\frac{1}{80000}$
36.	Little Egg harbor, New Jersey	$\frac{1}{30000}$
37.	Delaware bay and river, sheet No. 1, Delaware	$\frac{1}{80000}$
38.	Do..........do..........do. No. 2, New Jersey and Pennsylvania	$\frac{1}{80000}$
39.	Do..........do..........do. No. 3	$\frac{1}{80000}$
40.	Harbor of Annapolis and Severn river, Maryland	$\frac{1}{60000}$
41.	Mouth of Chester river, Maryland	$\frac{1}{40000}$
42.	Pasquotank river, North Carolina	$\frac{1}{60000}$
43.	Charleston harbor, South Carolina	$\frac{1}{30000}$
44.	Key West harbor and its approaches, Florida	$\frac{1}{50000}$
45.	Mobile bay and entrance, Alabama	$\frac{1}{40000}$
46.	Mobile bay, Alabama	$\frac{1}{80000}$
47.	Cat and Ship Islands harbors, Mississippi	$\frac{1}{40000}$
48.	Galveston bay entrance, Texas	$\frac{1}{40000}$

2. List of Preliminary Charts and Sketches engraved.

No. 1.	Alden's rock, Maine	$\frac{1}{1000}$
2.	Eggemoggin reach, Maine	$\frac{1}{20000}$
3.	Portland harbor, Maine.	$\frac{1}{20000}$
4.	Portland harbor, (Commissioners' line,) Maine	$\frac{1}{10000}$
5.	York River harbor, Maine.	$\frac{1}{20000}$
6.	Portsmouth harbor, New Hampshire	$\frac{1}{20000}$
7.	Annis Squam and Ipswich harbors, Massachusetts	$\frac{1}{20000}$
8.	Stellwagen's bank, 2d edition, Massachusetts	$\frac{1}{400000}$
9.	Boston bay, Massachusetts	$\frac{1}{175000}$
10.	Current chart, Boston harbor, Massachusetts	$\frac{1}{100000}$
11.	Minot's ledge, Massachusetts	$\frac{1}{10000}$
12.	Plymouth harbor, Massachusetts.	$\frac{1}{20000}$
13.	Monomoy shoals, Massachusetts	$\frac{1}{40000}$
14.	Nantucket shoals, Massachusetts—new edition.	$\frac{1}{200000}$
15.	Tidal currents, Nantucket shoals, Massachusetts.	$\frac{1}{300000}$
16.	Muskeget channel, Massachusetts	$\frac{1}{60000}$
17.	Sow and Pigs reef, Massachusetts	$\frac{1}{240}$, $\frac{1}{20000}$
18.	Tidal currents, Long Island sound, Massachusetts	$\frac{1}{800000}$
19.	Pot rock and Way's reef, New York	
20.	Hudson river, lower sheet.....do	$\frac{1}{60000}$
21.	Buttermilk channel............do	$\frac{1}{5000}$
22.	Beacon ranges, New York harbor	$\frac{1}{40000}$
23.	Romer shoal and Flynn's knoll, New York	$\frac{1}{40000}$
24.	Changes in Sandy Hook, New Jersey	$\frac{1}{10000}$, $\frac{1}{40000}$
25.	Seacoast of Delaware, Maryland, and part of Virginia	$\frac{1}{200000}$
26.	Delaware and Chesapeake bays	$\frac{1}{400000}$
27.	Chincoteague inlet, Virginia	$\frac{1}{40000}$
28.	Seacoast of Virginia and entrance to Chesapeake bay, Virginia	$\frac{1}{200000}$, $\frac{1}{100000}$
29.	James river, (upper sheet,) Virginia	$\frac{1}{40000}$
30.	Wachapreague, Machipongo, and Metomkin inlets, Virginia	$\frac{1}{40000}$
31.	Ship and Sand Shoal inlets, Virginia	$\frac{1}{40000}$
32.	Entrance to Chesapeake bay.....do	$\frac{1}{100000}$
33.	Cape Charles and vicinity........do	$\frac{1}{80000}$
34.	Cherrystone inlet..................do	$\frac{1}{40000}$
35.	Pungoteague creek................do	$\frac{1}{40000}$
36.	Fishing or Donoho's battery, Maryland	$\frac{1}{80000}$
37.	Albemarle sound	$\frac{1}{200000}$
38.	Diagrams showing the effect of the wind in elevating or depressing the water in Albemarle sound	
39.	Hatteras shoals, North Carolina	$\frac{1}{20000}$
40.	Cape Hatteras...........do	$\frac{1}{20000}$
41.	Hatteras inlet...........do............fourth edition	$\frac{1}{20000}$
42.	Ocracoke inlet...........do	$\frac{1}{40000}$
43.	Wimble shoals ....do	$\frac{1}{80000}$
44.	Beaufort harbor.........do	$\frac{1}{20000}$
45.	Do................do............on steel	$\frac{1}{20000}$, $\frac{1}{30000}$
46.	New river and bar......do	$\frac{1}{15000}$
47.	Frying-pan shoals......do	$\frac{1}{120000}$

48.	Cape Fear river and New inlet, North Carolina	$\frac{1}{40000}$
49.	Do.........do.........do.........No. 1	$\frac{1}{80000}$
50.	Gulf Stream explorations, 1853	$\frac{1}{5000000}$
51.	Diagrams, Gulf Stream explorations, 1853	
52.	Gulf Stream explorations, 1854	$\frac{1}{5000000}$
53.	Diagrams, Gulf Stream explorations, 1854	
54.	Gulf Stream explorations, 1855	$\frac{1}{5000000}$
55.	Cotidal lines, Atlantic coast	$\frac{1}{10000000}$, $\frac{1}{15000000}$
56.	Cape Roman shoals, South Carolina	$\frac{1}{100000}$
57.	Winyah bay and Cape Roman shoals, South Carolina	$\frac{1}{100000}$
58.	Winyah bay and Georgetown harbor.........do	$\frac{1}{40000}$
59.	Bull's bay.........do	$\frac{1}{40000}$
60.	Comparative chart, Maffitt's channel.........do	$\frac{1}{5000}$
61.	Maffitt's channel—sections.........do	$\frac{1}{5000}$
62.	North Edisto river, (new edition).........do	$\frac{1}{50000}$
63.	Romerly marshes.........do	$\frac{1}{10000}$
64.	Savannah river entrance, Georgia	$\frac{1}{30000}$
65.	Savannah city—Front and Back rivers, Georgia	$\frac{1}{20000}$
66.	Savannah river, Georgia	$\frac{1}{40000}$
67.	Doboy bar and inlet, Georgia	$\frac{1}{40000}$
68.	St. Andrew's shoals......do	$\frac{1}{60000}$
69.	St. John's river entrance, Florida	$\frac{1}{25000}$
70.	Mosquito inlet.........do	$\frac{1}{40000}$
71.	Cape Cañaveral.........do	$\frac{1}{60000}$
72.	Turtle harbor, Florida reefs..do	$\frac{1}{40000}$
73.	Beacons on Florida reefs......do	
74.	Coffin's Patches.........do	$\frac{1}{20000}$
75.	Key Biscayne, Cape Sable, and bases	$\frac{1}{400}$, $\frac{1}{600000}$
76.	Legaré anchorage, Florida	$\frac{1}{20000}$
77.	Key West harbor......do...second edition	$\frac{1}{100000}$
78–84.	Key West tidal diagrams, Florida	
85.	Rebecca shoal.........do	$\frac{1}{600000}$
86.	Reconnaissance vicinity of Cedar keys, Florida	$\frac{1}{300000}$
87.	Channel No. 4, Cedar keys, Florida	$\frac{1}{30000}$
88.	Cedar keys and approaches......do	$\frac{1}{50000}$
89.	Ocilla river.........do	$\frac{1}{20000}$
90.	St. Mark's bar and channel.....do	$\frac{1}{40000}$
91.	Middle or main and western entrances, St. George's sound, Florida.	$\frac{1}{80000}$
92.	St. Andrew's bay, Florida	$\frac{1}{40000}$
93.	Entrance to Mobile bay, Alabama	$\frac{1}{80000}$
94.	Mobile bay, (2d edition,).....do	$\frac{1}{200000}$
95.	Horn Island pass and Grand bay, Mississippi	$\frac{1}{300000}$
96.	Do.........do.........new edition	$\frac{1}{40000}$
97.	Pascagoula river.........do	$\frac{1}{20000}$
98.	Biloxi bay.........do	$\frac{1}{40000}$
99–108.	Cat Island tidal diagrams.........do	
109.	Pass Christian.........do	$\frac{1}{40000}$
110.	Delta of Mississippi, Louisiana	$\frac{1}{60000}$
111.	Deep-sea soundings, Gulf of Mexico	$\frac{1}{2400000}$
112.	Barataria bay entrance, Louisiana	$\frac{1}{30000}$
113.	Pass Fourchon.........do	$\frac{1}{10000}$

114. Timballier bay entrance, Louisiana.......... $\frac{1}{20000}$

115. Isle Dernière or Ship Island shoals.......... $\frac{1}{80000}$

116. Entrances to Vermilion bay and Calcasieu river.......... $\frac{1}{30000}$, $\frac{1}{40000}$

117. Sabine Pass, Texas.......... $\frac{1}{40000}$

118. Entrance to Galveston bay, Texas.......... $\frac{1}{40000}$

119. Galveston bay—4th edition...do.......... $\frac{1}{200000}$

120. San Luis Pass..........do.......... $\frac{1}{20000}$

121. Aransas Pass—2d edition ....do.......... $\frac{1}{30000}$

122. Entrance to Rio Grande.......do.......... $\frac{1}{20000}$

123. Alden's reconnaissance Western Coast, lower sheet, San Francisco to San Diego—new edition—California.......... $\frac{1}{1200000}$

124. Cortez bank.......... $\frac{1}{10000}$, $\frac{1}{1200000}$

125. San Diego entrance, (new edition,) California.......... $\frac{1}{15000}$, $\frac{1}{25000}$

126. Geological map of San Diego..........do.......... $\frac{1}{1608228}$

127. Catalina harbor.......... $\frac{1}{15000}$

128. San Pedro anchorage and vicinity of Santa Barbara, California.......... $\frac{1}{20000}$, $\frac{1}{40000}$

129. Anacapa island, (sketch)..........do..........

130. Do..........do.......... $\frac{1}{30000}$

131. Prisoner's harbor, Cuyler's harbor, and northwest anchorage San Clemente island, California.......... $\frac{1}{2000}$

132. Santa Barbara, California.......... 1

133. San Simeon, Santa Cruz, San Luis Obispo, and Coxo harbors.......... $\frac{1}{20000}$, $\frac{1}{40000}$

134. Point Conception.......... $\frac{1}{40000}$

135. Point Pinos.......... $\frac{1}{20000}$

136. Monterey harbor, California.......... $\frac{1}{40000}$

137. Geological map of Monterey, California.......... $\frac{1}{150000}$

138. Santa Cruz and Año Nuevo harbors.......... $\frac{1}{40000}$, $\frac{1}{1200000}$

139. San Pedro harbor, California.......... $\frac{1}{20000}$

140. San Francisco bay entrance, California.......... $\frac{1}{400000}$

141. San Francisco city—3d edition ...do.......... $\frac{1}{10000}$

142. Geological map San Francisco....do.......... $\frac{1}{150000}$

143. South Farallon island..........do..........

144. Tidal diagrams, Rincon Point....do..........

145. Pulgas base..........do.......... $\frac{1}{40000}$, $\frac{1}{400000}$

146. Mare Island straits..........do.......... $\frac{1}{30000}$

147. Alden's reconnaissance Western Coast, middle sheet, San Francisco to Umpquah river, California and Oregon.......... $\frac{1}{1200000}$

148. McArthur's reconnaissance Western Coast, from Monterey to mouth of Columbia river, sheet No. 1—3d edition..........

149. McArthur's reconnaissance Western Coast, from Monterey to mouth of Columbia river, sheet No. 2—3d edition..........

150. McArthur's reconnaissance Western Coast, from Monterey to mouth of Columbia river, sheet No. 3—3d edition..........

151. Alden's reconnaissance Western Coast, northern sheet.......... $\frac{1}{1200000}$

152. Point Reyes and Drake's bay, California.......... $\frac{1}{40000}$

153. Geological map Point Reyes ....do.......... $\frac{1}{150000}$

154. Humboldt bay..........do.......... $\frac{1}{30000}$

155. Trinidad bay..........do.......... $\frac{1}{20000}$

156. Shelter cove, Mendocino City, and Crescent City harbors, and Port Orford Ewing harbor, California and Oregon.......... $\frac{1}{20000}$

157. Umpquah river, Oregon.......... $\frac{1}{20000}$

158. Mouth of Columbia river—2d edition—Oregon .... $\frac{1}{40000}$
159. Do..........do..........do.......... $\frac{1}{200000}$
160. Entrance to Columbia river..........do.......... $\frac{1}{40000}$
161. Tidal diagrams Rincon Point, San Diego, and Astoria, California and Oregon ....
162. Cotidal lines of the Pacific Coast.......... $\frac{1}{10000000}$
163. Cape Disappointment, Washington Territory.......... $\frac{1}{20000}$
164. Shoalwater bay..........do.......... $\frac{1}{80000}$
165. Alden's reconnaissance Western Coast, from Gray's harbor to Admiralty inlet, Washington Territory.......... $\frac{1}{600000}$
166. Grenville harbor, Washington Territory.......... $\frac{1}{20000}$
167. Cape Flattery and Neé-ah harbor, Washington Territory.......... $\frac{1}{40000}$
168. False Dungeness harbor.......... $\frac{1}{30000}$
169. Canal de Haro and Strait of Rosario and approaches, Washington Territory.......... $\frac{1}{200000}$, $\frac{1}{600000}$
170. Washington Sound, Washington Territory.......... $\frac{1}{400000}$
171. Port Townshend..........do..........do.......... $\frac{1}{40000}$
172. Duwamish bay and Seattle harbor, Washington Territory.......... $\frac{1}{40000}$
173. Smith's or Blunt's island..........do..........do.......... $\frac{1}{20000}$
174. Base apparatus..........
175. Self-registering tide-gauge..........
176. Craven's current-indicator..........
177. Craven's specimen box for deep-sea soundings..........
178. Mitchell's seacoast tide-gauge ....
179. Figures to illustrate Appendix No. 33, 1854 ....
180. Diagrams of secular variation in magnetic declination, 1855..........
181. Diagrams illustrating earthquake waves at San Diego and San Francisco ..
182. Diagrams of secular variation in magnetic declination, 1856..........
183. Lines of equal magnetic declination .... $\frac{1}{15000000}$
184. Boutelle's scaffold for stations and Farley's signal..........
185. Boutelle's apparatus for measuring preliminary bases..........
186. Sands' gas-pipe tripod..........
187. Sands' specimen box for deep-sea soundings and revolving heliotrope ....
188–213. Progress sketches..........

List of maps, preliminary charts, and sketches, engraved or engraving during the year ending November 1, 1856—arranged in order of sections.

Name.	Scale.	Description.	Remarks.
SECTION I.			
Progress sketch A	1-600,000	....	Engraved.
Do.....A *bis*	1-400,000		Do.
Portland harbor	1-20,000	Finished chart	Engraving.
Portland harbor, Commissioners' line	1-10,000	Sketch	Engraved.
Ipswich and Annis Squam harbors	1-20,000	Preliminary chart	Do.
Gloucester harbor	1-20,000	Finished chart	Do.
Boston bay	1-175,000	Sketch	Do.
Boston harbor	1-40,000	Finished chart	Do.
Stellwagen's bank, 2d edition	1-400,000	Preliminary chart	Do.
Plymouth harbor	1-20,000	Finished chart	Engraving.
Monomoy shoals	1-40,000	......do	Do.

List of maps, preliminary charts, &c.—Continued.

Name.	Scale.	Description.	Remarks.
SECTION I—Continued.			
Bass river harbor	1-40,000	Finished chart	Engraved.
Muskeget channel	1-60,000	do	Engraving.
Eastern series, No. 1	1-80,000	do	Do.
Do No. 2	1-80,000	do	Do.
SECTION II.			
Progress sketch B	1-800,000		Engraved.
Progress Hudson river triangulation	1-400,000		Do.
South side Long Island, No. 3	1-80,000	Finished chart	Engraving.
Do do No. 2	1-80,000	do	Do.
Hudson river, lower sheet	1-60,000	Preliminary chart	Engraved.
SECTION III.			
Progress sketch C	1-400,000		Do.
Seacoast Virginia, and entrance to Chesapeake bay	1-100,000 1-200,000	Preliminary chart	Do.
Delaware and Chesapeake bays	1-400,000	do	Do.
Chesapeake bay, No. 1	1-80,000	Finished chart	Engraving.
Do No. 2	1-80,000	do	Do.
Patapsco river	1-60,000	do	Do.
Rappahannock river, No. 3	1-20,000	Preliminary chart	Do.
Do No. 4	1-20,000	do	Do.
James river, upper sheet	1-40,000	do	Engraved.
SECTION IV.			
Progress sketch D	1-400,000		Do.
Cape Fear river, lower	1-30,000	Preliminary chart	Do.
Do upper	1-30,000	do	Engraving.
Albemarle sound	1-200,000	do	Engraved.
Do No. 2	1-80,000	Finished chart	Engraving.
Beaufort harbor, N. C	1-20,000	do	Do.
Gulf steam explorations, 1855	1-5,000,000	Sketch	Engraved.
Isogonic lines east coast	1-5,000,000	do	Engraving.
Diagrams showing the effect of the wind in raising or depressing the water in Albemarle sound.		Diagram	Engraved.
SECTION V.			
Progress sketch E	1,400,000		Do.
Winyah bay and Georgetown harbor	1-40,000	Preliminary chart	Do.
Maffitt's channel, sections		Diagram	Do.
Port Royal entrance	1-60,000	Preliminary chart	Engraving.
Romerly marshes	1-10,000	do	Engraved.
Savannah river	1-40,000	do	Do.
SECTION VI.			
Progress sketch F	1-1,200,000		Do.
Progress Florida reefs	1-400,000		Do.
Progress St. John's river triangulation	1-200,000		Do.
Key Biscayne and Cape Sable bases	1-60,000 1-400,000		Do.
Beacons on Florida reefs		Sketch	Do.
Legaré anchorage	1-20,000	Reconnaissance	Do.
Tampa bay	1-120,000	do	Do.
SECTION VII.			
Progress sketch G	1,600,000		Do,
Cedar keys and approaches	1-50,000	Preliminary chart	Do.
St. Andrew's bay	1-40,000	do	Do.

List of maps, preliminary charts, &c.—Continued.

Name.	Scale.	Description.	Remarks.
SECTION VIII.			
Progress sketch H	1-600,000		Engraved.
Mobile bay	1-80,000	Finished chart	Do.
Mississippi sound, No. 1	1,80,000	do	Engraving.
Seacoast of part of Alabama and Mississippi	1,200,000	Preliminary chart	Do.
Biloxi bay	1-40,000	Preliminary chart	Engraved.
Deep-sea soundings, Gulf of Mexico	1-2,400,000	Sketch	Do.
Co-tidal lines, Gulf of Mexico	1-10,000	do	Engraving.
SECTION IX.			
Progress sketch I	1-600,000		Engraved.
Galveston bay	1-200,000	Preliminary chart	Do.
SECTIONS X & XI.			
Progress sketch J	1-400,000		Do.
Do K	1-7,000,000		Do.
Progress San Pedro and vicinity	1-1,200,000		Do.
Progress Washington sound	1-400,000		Do.
Anacapa island	1-30,000	Sketch	Engraving.
San Francisco entrance	1-50,000	Finished chart	Do.
South Farallon island		Sketch	Engraved.
Alden's reconnaissance, west coast, northern sheet	1-1,200,000	Reconnaissance	Do.
Port Ludlow	1-20,000	do	Engraving.
Bellingham bay	1-40,000	do	Do.
Steilacoom harbor	1-30,000	do	Do.
Port Gamble	1-20,000	do	Do.
Geological map, Point Reyes	1-150,000	Sketch	Engraved.
Do San Francisco	1-150,000	do	Do.
Do Monterey	1-150,000	do	Do.
Do San Diego	1-1,608,228	do	Do.
Co-tidal lines, Pacific coast	1-10,000,000	do	Do.
Earthquake waves, Pacific coast		Diagram	Do.
Boutelle's scaffold for stations and Farley's signal		Sketch	Do.
Boutelle's apparatus for measuring preliminary bases		do	Do.
Sand's gas-pipe tripod		do	Do.
Sand's specimen-box for deep-sea soundings, and revolving heliotrope.		do	Do.
Isogonic lines, west coast	1-5,000,000	do	Engraving.
Isogonic lines	1-15,000,000	do	Engraved.

Report of Mr. George Mathiot, in charge of the Electrotype Division.

UNITED STATES COAST SURVEY OFFICE, *November*, 1856.

Since the date of my last annual report, (November 1, 1855,) the work of the electrotype division has greatly increased; the product for this year being much above that of any former one. The number of electrotypes made amounts to nearly one hundred. Of this number thirty-seven altos and thirty-two bassos, or sixty-nine in all, were available for perpetuating the engraved plates, and for furnishing printed charts. The residue were used in experiments for ascertaining the practicability of printing from thin electrotypes, in the combining of engraved plates, and in researches on photo-electric engraving. Appended is a table of the charts electrotyped.

Important additions have been made to the apparatus of the electrotype laboratory; the voltaic batteries have been increased in number; an additional cell for decompositions has been provided, and an apparatus for purifying the solutions of sulphate of copper. This consists of a large evaporating pan surrounded with a jacket for hot water, which connects with a helical bath-heater similar in construction to that used for heating the electrolytes. The helical bath-heater is described in the Coast Survey Report for 1850. The accumulation of apparatus in the laboratory has proceeded as far as the size of the room will possibly admit. No further additions can be made, for very great inconvenience is already frequently felt from the want of space for the necessary manipulations. On this account the making of thin printing plates will have to be discontinued in the cold seasons, unless an addition is made to the building, or a larger one obtained, to admit of the use of apparatus for heating the electrolytes while the plates are in a vertical position.

The work of joining engraved plates has been applied to five charts of the survey. The views of Charleston harbor were inserted in the plate of the chart of Charleston harbor. Four views from the plate of the "reconnaissance from Grey's harbor to Admiralty Inlet" were transferred to "sheet No. 3 of Alden's West Coast reconnaissance." The views were inserted in "sheet No. 1 of Long Island sound." The plate of "Shoalwater bay" was extended. The plate of Boston harbor was enlarged, and the views set in it.

Assistance has been rendered to other portions of the Survey by gold plating fifteen deep-sea thermometers, and by arranging, constructing, and repairing the magnetic and voltaic apparatus of the parties for determining longitudes by means of the electric telegraph.

I have lately made experiments for ascertaining the practicability of printing from thin electrotypes merely folded over the edges of a stout plate of rough metal. The result has been to demonstrate that printing plates can be thus furnished for about one third of the cost of plates made of the usual thickness, and that they are in every respect equal to them for printing. I have already furnished for the printer such electrotypes from some of the most valuable charts of the Survey, as will appear by the accompanying table of thin plates. Though the advantage of the thin plates has been fully demonstrated, it will not be practicable to uniformly furnish them, on account of the want of suitable apparatus; when this is obtained, I will present a detailed report on the mode of producing these plates.

Somewhat has been done in the matter of actino engraving, though by no means so much as I desired. I had hopes of being able to send with this report a chart printed from an actino-engraved plate. In this I have been hindered only by the want of time, occasioned by the great press of electrotype work and the experiments on thin printing plates. For making a trial of the photo-electric process, I have constructed daguerreotype apparatus to execute a plate 13 by 13¼ inches. The difficulty and labor of this have been very great, as such large apparatus not being in market as a regular manufacture, I had to obtain the material from various sources, and execute most of the work of construction with my own hands; even the large daguerreotype plates I have had to make, the manufacturers of plates offering nothing of the size or quality required.

I have made a number of experiments on engraving small portions of charts, and have obtained specimens exhibiting very decided progress beyond former results. The last specimens indicate that a little further improvement will enable the photo-electric process to commence a rivalry with the lithograph, and even to contend with hand engraving.

LIST OF CHARTS ELECTROTYPED IN ALTO.

	Plates.
Mouth of Columbia river	1
Charleston harbor	2
Long Island sound (east)	3
Alden's reconnaissance Western Coast (northern sheet)	2
Alden's reconnaissance Western Coast, from Gray's harbor to Admiralty inlet	2
Gloucester harbor	1
Diagrams of magnetic variation	1
San Simeon, Santa Cruz, San Luis Obispo, &c.	1
Mare Island straits	1
Canal de Haro and Strait of Rosario and approaches	1
Nantucket shoals	2
York River harbor	1
Horn Island pass	1
Humboldt bay	1
Mobile bay	1
Portland harbor	1
Cedar keys and approaches	1
Patapsco river	1
Chincoteague inlet	1
James river	1
Gulf Stream sketch, 1855	1
Shoalwater bay	1
Minot's Ledge	1
Cape Fear river and New inlet	1
Port Townshend	1
Boston harbor	1
Albemarle sound	1
Galveston bay	1
Muskeget channel	1
Seacoast of Virginia, No. 2	1
Hudson river, B No. 2	1

LIST OF CHARTS ELECTROTYPED IN BASSO.

	Plates.
Charleston harbor	1
Harbors of Black Rock and Bridgeport	1
Santa Cruz and Año Nuevo harbors	1
General chart of the coast from Gay Head to Cape Henlopen	1
Long Island sound (east)	3
Nantucket harbor	1
Alden's reconnaissance Western Coast (northern sheet)	1
Alden's reconnaissance Western Coast, from Gray's harbor to Admiralty inlet	1
Gloucester harbor	1
Newburyport harbor	1
Mare Island straits	1
Canal de Haro and Strait of Rosario and approaches	1
Nantucket shoals	1
York river harbor	1
Horn Island pass	1
Alden's reconnaissance Western Coast (middle sheet)	1
Portland harbor	1
Cedar keys aud approaches	1
Patapsco river	1
Catalina harbor	1
Minot's Ledge	1
Port Townshend	1
Boston harbor	2
Shoalwater bay (extended)	1

LIST OF CHARTS EXTENDED OR ALTERED BY THE ELECTROTYPE PROCESS.

Charleston harbor.
Alden's reconnaissance Western Coast (northern sheet.)
Shoalwater bay.
Long Island sound (east.)
Boston harbor.

LIST OF THIN PLATES FURNISHED FOR PRINTING.

Horn Island pass.
Cedar keys and approaches.
Portland harbor.
Nantucket shoals.
Minot's Ledge.
Port Townshend.
Boston harbor.

Report of Mr. S. D. O'Brien on the printing of Coast Survey maps, charts, and sketches.

Since the first of November, 1855, there have been printed from the following plates:

SECTION I.

	No. of impressions.
Sketch A	20
Sketch A, *bis*	20
Portland harbor	250
Portland harbor, (Commissioners' line)	20
York River harbor	1,312
Gloucester harbor	1,012
Eggemoggin reach	100
Salem harbor	1,667
Newburyport harbor	1,250
Wellfleet harbor	400
Minot's ledge	134
Nantucket harbor	395
Nantucket shoals	320
Muskeget channel	30
Harbor of Edgartown	400
Hyannis harbor	400
Harbors of Holmes' Hole and Tarpaulin cove	100
Harbor of New Bedford	506
Ipswich and Annis Squam harbors	20
Stellwagen's bank	20

SECTION II.

Sketch B	20
Hudson river triangulation	20
General chart of the coast, from Gay head to Cape Henlopen	300
Long Island sound, No. 1	827
Long Island sound, No. 2	1,017
Long Island sound, No. 3	720
Fisher's Island sound	250
Mouth of Connecticut river	250
Harbor of New Haven	650
Huntington bay	235
Harbors of Black Rock and Bridgeport	400
Captain's island, east and west	400
Hart and City island, and Sachem's Head harbors	400
Hell Gate	510
New York bay and harbor	640
Hudson river (lower part)	25
Changes in Sandy Hook	100
Romer shoal and Flynn's knoll	100
Little Egg harbor	400

Section III.

	No. of impressions.
Sketch C	20
Seacoast of Virginia, No. 2	30
Mouth of Chester river	400
Pungoteague Creek	100
Wachapreague inlet	100

Section IV.

Sketch D	20
New river and bar	400
Albemarle sound	20
Cape Fear river	20
Wimble shoals	100
Gulf Stream explorations	46
Gulf Stream sketch	45

Section V.

Sketch E	20
Charleston harbor	1,142
Maffitt's channel (sections)	20
Winyah bay	100
Bull's bay	100
Romerly marshes	20
Doboy inlet	20

Section VI.

Sketch F	20
Sketch F, No. 2	20
Key West harbor	1,370
Beacons on Florida reefs	20
Coffin's patches	100
Entrance to St. George's sound	20
Legaré anchorage	20
Tampa bay	20
Cape Sable and Key Biscayne bases	20
St. John's river triangulation	10

Section VII.

Sketch G	20
Reconnaissance, in vicinity of Cedar Keys	100
Cedar Keys	145
St. Andrew's shoal	100
Ocilla river	20

SECTION VIII.

	No. of impressions.
Sketch H	20
Mobile bay, $\frac{1}{200000}$	400
Mobile bay, $\frac{1}{80000}$	12
Biloxi bay	20
Pascagoula river	100
Ship Island shoal	20
Deep-sea soundings, Gulf of Mexico	20
Horn Island pass	402
Delta of Mississippi	200

SECTION IX.

Sketch I	20
Galveston bay	420
Entrance to Galveston bay	980
Vermilion bay	20
Entrance to Rio Grande river	20

SECTIONS X, XI.

Sketch J	20
Sketch J, No. 2	20
Sketch J, No. 3	20
Reconnaissance from San Francisco to San Diego	600
Reconnaissance from San Francisco to Umpquah river	600
Reconnaissance from Umpquah river to the boundary	455
San Diego bay	700
Monterey harbor	400
Humboldt bay	400
Santa Barbara	15
San Simeon, Santa Cruz, San Luis Obispo, and Coxo harbors	400
Santa Cruz and Año Nuevo	350
San Francisco city	100
Entrance to Umpquah river	300
Shoalwater bay	700
Reconnaissance from Gray's harbor to Admiralty inlet, W. T.	350
Cape Flattery	300
Port Townshend	250
San Pedro	400
Point Pinos	150
Point Conception	100
Mare Island straits	500
Cape Hancock	100
Grenville harbor	100
Duwamish bay	100
Canal de Haro	695
San Pedro and Santa Barbara anchorages	20
South Farrallon island	20

	No. of impressions.
Point Reyes	20
Co-tidal lines, Pacific coast	20
San Diego bay triangulation	30
Columbia river triangulation	30
Earthquake waves, Pacific coast	20
Magnetic declinations	20
Isogonic lines	40
Geological map Point Reyes	120
Geological map San Francisco bay	20
Geological map Monterey bay	20
Geological map San Diego	120

MISCELLANEOUS.

Proofs of finished and unfinished plates	1,737
Circular protractors	54
Current diagrams	150
Tidal diagrams	942
Specimen box for deep-sea soundings	28
Gas-pipe tripod	20
Boutelle's base apparatus	20
Boutelle's scaffold	30
Map of Washington city	67
	34,695

Report of Mr. V. E. King on the distribution and sale of maps.

At the date of my last report, October 1, 1855, fifty-seven sheets of Coast Survey maps had been published. Since then the following charts have been added, which will make the number now published sixty-three; viz:

York river harbor.
Gloucester harbor.
Bass River harbor.
Boston harbor.
Mobile bay, $\frac{1}{80000}$.
Reconnaissance of the Western Coast, from Umpquah river to the boundary.

The following preliminary charts have also been added to the published matter during the year; viz:

Minot's ledge.
Cape Fear river and New inlet.
Ship Island shoal.
Santa Cruz and Año Nuevo.
Port Orford, Shelter cove, Mendocino City and Crescent City harbor.
Port Townshend.
Canal de Haro.

The list of sketches for gratuitous distribution has been increased by the following; viz:

Eggemoggin Reach.

Sow and Pigs reef.
Romer shoal and Flynn's knoll.
Wachapreague, Machipongo, and Metomkin inlets.
Ship and Sand-shoal inlets.
Cape Charles and vicinity.
Cherrystone inlet.
Pungoteague creek.
Wimble shoals.
Winyah bay and Cape Roman shoals.
Turtle harbor.
Coffin's Patches.
Entrance to St. George's sound.
Entrance to Pascagoula river.
Entrance to Barataria bay.
Pass Fourchon.
Entrance to Timballier bay.
Sabine Pass.
Entrance to Rio Grande river.
Grenville harbor.
Duwamish bay and Seattle harbor.

A second edition of the volume of bound maps, mentioned in my report of November 1, 1854, is now nearly completed. The number of volumes will be 400, which will be distributed principally as those published in 1854.

There is also in progress the printing of 250 portfolios of maps, embracing the general chart of the Bay of the five States, with those that are published of Section II: New York bay and harbor, recently re-surveyed; and the harbors of Long Island sound. These will be distributed to Coast Survey agents for sale.

List of Coast Survey maps distributed during the year, for sale, use of office, and gratuitously.

Names of Charts.	Turned over for sale.	For use of office.	Gratuitously distributed.	Total.
Richmond's Island harbor	10	2	82	97
York River harbor	8	1	31	40
Newburyport harbor	24	8	265	297
Gloucester harbor	11	5	58	74
Salem harbor	87	7	312	406
Wellfleet harbor	7	4	123	134
Nantucket harbor	15	3	72	90
Harbor of Edgartown	13	3	67	83
Hyannis harbor	13	5	68	86
Harbors of Holmes' Hole and Tarpaulin Cove	13	5	65	83
Harbor of New Bedford	13	7	127	147
General coast chart from Gay Head to Cape Henlopen	55	5	97	157
Long Island sound	163	2	69	234
Fisher's Island sound	28	3	48	79
Harbor of New London	23	6	76	105
Mouth of Connecticut river	5	4	124	133
Harbor of New Haven	23	4	70	97
Harbors of Black Rock and Bridgeport	23	4	65	92
Huntington bay	23	4	64	91
Harbors of Sheffield and Cawkin's Island	13	4	65	82
Harbors of Captains' island, east and west	13	4	65	87
Harbor of Oyster bay, or Syosset harbor	18	3	60	81
Hart and City island, and Sachem's Head harbor	8	4	66	78
Hell Gate	8	5	84	97
New York bay and harbor, and the environs, $\frac{1}{30000}$	8	2	9	19

List of Coast Survey maps distributed, &c.—Continued.

Names of Charts.	Turned over for sale.	For use of office.	Gratuitously distributed.	Total.
New York bay and harbor, and the environs, $\frac{1}{80000}$	150	10	109	269
Western part of south coast of Long Island	8	3	69	80
Little Egg Harbor	8	3	77	88
Delaware bay and river	10	7	105	122
Seacoast of Delaware, Maryland, and part of Virginia		4	86	90
Mouth of Chester river	8	2	69	79
Harbor of Annapolis and Severn river	8	3	133	144
Pasquotank river	8	3	70	81
Charleston harbor	194	16	198	408
Cat and Ship Island harbors	8	3	65	76
Mobile bay, entrance	18	17	71	106
Galveston entrance		17	123	140
Key West harbor, and approaches	213	5	187	405
West Coast reconnaissance, from San Diego to San Francisco	70	3	140	213
West Coast reconnaissance, from San Francisco to Umpquah river	63	3	88	153
West Coast reconnaissance, from Umpquah river to the boundary	5		40	45
San Diego bay, and approaches	58	2	73	133
Trinidad bay	58	3	70	131
Humboldt bay	58	3	72	133
Monterey harbor	58	3	70	131
Entrance to Columbia river	58	3	134	195
Sketches of—Minot's ledge	8		12	17
Nantucket shoals	10	2	74	86
Chincoteague inlet		2	64	66
Ocracoke inlet		3	74	77
Beaufort harbor, N. C.	8	2	60	70
Frying-Pan shoals	8	4	61	73
New river and bar	8	2	61	71
Cape Fear river and New inlet	5		12	17
North Edisto	8	2	67	77
Entrance to Savannah river	8	3	61	72
Savannah city, Front and Back rivers	8	3	59	70
Mobile bay	20	3	75	98
Western coast of Florida	7	2	37	46
St. Mark's bar and channel	8	4	72	84
Entrance to St John's river	5	3	126	134
Delta of the Mississippi	9	3	64	76
Ship Island shoal	5		12	17
Galveston bay	9	3	62	74
San Luis Pass	7	2	125	133
Catalina harbor	39	2	66	107
Prisoner's, Cuyler's, and San Clemente harbors	59	2	65	126
Santa Barbara	56	2	198	256
San Simeon, Santa Cruz, &c.	51	3	65	119
Santa Cruz and Año Nuevo	51	2	44	97
San Pedro harbor	59	2	92	153
San Francisco city	21	4	82	107
Port Orford, Shelter Cove, &c.				
Entrance to Umpquah river	56	3	196	255
Shoalwater bay	56	3	171	260
Reconnaissance from Gray's harbor to Admiralty inlet	56	2	202	260
Cape Flattery and Neé-ah harbor	56	2	202	260
False Dungeness harbor	56	3	182	241
Port Townshend			12	12
Canal de Haro	50		35	85
Eggemoggin Reach			27	27
Current chart, Boston harbor	18	2	48	68
Sow and Pigs reef			27	27
Romer and Flynn's shoals			27	27
Changes in Sandy Hook	8	2	49	59
Wachapreague, Machipongo, &c			28	22
Ship and Sand Shoal inlets			28	28
Entrance to Chesapeake bay	14	2	42	58
Cape Charles and vicinity			27	27
Cherrystone inlet			28	28
Pungoteague creek			28	28
Fishing or Donoho's battery	8	2	34	44
Hatteras shoals	8	2	37	47
Hatteras inlet	8	2	49	59
Wimble shoals			27	27

List of Coast Survey maps distributed, &c.—Continued.

Names of Charts.	Turned over for sale.	For use of office.	Gratuitously distributed.	Total.
Sketches of—Winyah bay and Cape Roman shoals	----------	----------	27	27
Bull's bay	8	2	35	45
St. Andrew's shoal	9	2	33	44
Mosquito inlet	9	2	45	56
Cape Cañaveral	9	2	33	44
Rebecca shoal	9	2	46	57
Turtle harbor	----------	----------	27	27
Coffin's patches	----------	----------	28	28
Reconnaissance in the vicinity of Cedar Keys	9	2	48	59
Channel No. 4, Cedar Keys	9	2	47	58
Entrance to St. George's sound	----------	1	28	29
Horn Island Pass, Grand bay	9	2	48	59
Entrance to Pascagoula river	----------	----------	26	26
Pass Christian	9	2	38	49
Entrance to Barataria bay	----------	----------	28	28
Pass Fourchon	----------	----------	29	29
Entrance to Timballier bay	----------	----------	28	28
Aransas Pass	9	2	47	58
Sabine Pass	----------	----------	28	28
Entrance to Rio Grande river	----------	----------	29	29
Mare Island straits	34	2	51	87
Point Conception	54	2	39	95
Point Pinos	59	2	51	112
Cape Disappointment	34	2	51	87
Grenville harbor	20	----------	29	49
Duwamish bay and Seattle harbor	50	----------	29	79
Total	2,898	330	8,528	11,756

APPENDIX No. 20.

Report of Dr. B. A. Gould, Jr., assistant in charge of telegraph operations for determining difference of longitude between Wilmington, N. C., and Montgomery, Ala.

CAMBRIDGE, *November* 11, 1856.

DEAR SIR: The report submitted to you upon the telegraphic operations for longitudes, during the year ending October, 1855, was written upon the eve of my departure for Europe, for the purpose of making the requisite arrangements for the construction of a heliometer, meridian circle, and normal clock, contributed by the citizens of Albany, towards the equipment of the Dudley observatory of that city, and primarily to be used in measurement of the Pleiades, and for providing a new and larger transit instrument for the Coast Survey. The duration of my absence was but three months, during which period the chief workshops for astronomical instruments upon the Eastern continent were visited, as well as the chief observatories of the continent and England. The results, as already reported in detail, have, I trust, been found satisfactory; and information has already been received of the completion and packing of the transit instrument, which will, I am confident, be found to have no superior. It has been made by Messrs. Pistor and Martins, of Berlin—has an object-glass of six French inches aperture and eight English feet focal length, and is provided with all the auxiliaries which the progress of instrumental art and astronomical requirement seemed to indicate as chiefly desirable. The other instruments, with the exception of the heliometer, were also contracted for, and full reports have already been presented. The heliometer—the means for which had been provided in consequence of your advice, and for the sake of the observations of the Pleiades needed by the Coast Survey—was not ordered in Europe; but after very mature reflection and conference, its construction has, with the entire approval of the trustees of the observatory, been intrusted to Mr. Spencer, of Canastota, N. Y., who has at present made considerable progress in the preparation of the plans.

The Hardy clock had been entirely refitted during the year by Mr. Saxton, and rendered much less difficult of management than formerly; and the reversal of transit instrument No. 6 had been much facilitated by the addition of an apparatus for lifting the axis from the Y's through the agency of an eccentric cam. This, although attended with the serious inconvenience of requiring a semi-cylindrical cavity to be cut in the stone for receiving the cam, is found to be in other respects a material advantage, and is preferred by the observers to the arrangement with a levelled wheel and screw as in transit No. 8, the former requiring less time by half.

The new portable clock ordered in June, 1855, of Mr. Krille, of Altona, had not been received, nor has it arrived even at the present time, to the serious disadvantage of the work, although it was promised for November of last year. Its arrival would have enabled the longitude parties to dispense with the Hardy clock, the length of which, as well as its mercurial pendulum, are but ill suited for constant transportation. I am unable to assign any valid reason for this extraordinary delay. The telegraphic campaign between Wilmington and Columbia, recommended in my last report, was entered upon at your direction by Messrs. Dean and Goodfellow, immediately on the completion of their summer labors with you, and observations commenced with the month of December. The ordinary delays, obstacles, and embarrassments were encountered, and the unaccustomed intensity of the cold introduced a new source of annoyance, in the freezing of the ink in the chronograph pens, an occurrence not anticipated in that latitude. It is not probable that this will in any manner impede the operations of the coming season, all of which are to be in latitudes south of 32° 23′; but aproper regard for the future extension of operations demands some means of escaping this difficulty in subsequent years, and my friend, Professor Horsford, of this city, has devoted considerable thought and experiment to the discovery of an ink adapted to the wants of chronographic registration and free from the danger of freezing at ordinary atmospheric temperatures. His results promise success at no distant date, if indeed they may not be considered as entirely satisfactory at present; but some further experiments appear desirable before any full expression of opinion. The importance of the problem is extreme, and not less so for fixed observatories throughout the zones in which those of the northern hemisphere are situated than for the temporary longitude stations of the Coast Survey.

Immediately upon my return to America, I hastened southward, visiting the stations at Wilmington and Columbia, and passing on to Mobile and New Orleans, in both of which latter cities careful examination was made before deciding upon sites for the stations of the following winter. The alluvial character of the soil will render especial precautions and devices necessary in New Orleans, which have been given in detail in my special report upon the sites selected.

Mr. McDonnell had in the interval refitted the Macon observatory and built a new station at Montgomery in the grounds of the State-house, and within a few yards east of that building.

The Wilmington-Columbia campaign was concluded during the last week of February, and Messrs. Dean and Goodfellow passed on to the next link of the westward chain, the stations Macon and Montgomery. By the skill and untiring energy of these gentlemen, this campaign was rendered the shortest upon record, and entirely the most successful as regards the promptness and completeness with which the prescribed number of star exchanges and of night's work in each position of observers was attained; these exchanges having been made on eight nights, beginning March 23, and ending April 24, and all observations of every kind being included between the dates March 8 and April 26. This was the more striking since, during a considerable portion of the time, Mr. Dean was seriously ill, and moreover abandoned in the midst of work by the aid upon whom he was almost entirely dependent for assistance.

During the progress of the Macon-Montgomery campaign, the Mobile station was constructing by Mr. McDonnell in the public square, which appeared the most satisfactory of all the available sites. It differs from the more northern ones only in being lower at the eaves, to permit of observations of the inferior transits of circumpolar stars. The roof boards were strongly braced by transverse boards to prevent warping during the summer, under the powerful influence of the almost zenithal sun.

Returning north at the close of March, I visited Mr. Dean in Montgomery and Mr. Goodfellow in Macon, at the completion of star exchanges in the first position of observers, making observations with Mr. Dean for personal equation.

During this interval of six months, the reductions could, of course, make but small progress. The simple though laborious reading of registers went on in duplicate with regularity, but, beyond this, little advance was made; and circumstances which prevented me from receiving until long after midsummer sufficient force for pressing forward the reductions with the desired rapidity, have acted, together with the material impairment of my health and the heavy responsibility of additional duties, to render the progress of this work less satisfactory than I could have wished. The force is now sufficient to justify the expectation that before the time for my next annual report, no back work whatsoever will remain unreduced.

It has seemed but proper, while carrying on the reductions, to put them in such a form as to be readily available for the volume of results of the telegraphic operations, for which you have directed me to prepare the materials. No exertions have been spared to hasten this desirable end; and recent publications of European astronomers, who adopt and give, as new, the identical methods used by the Coast Survey eight or nine years since, and only abandoned after superior means had been devised for the attainment of the same end, indicate the importance to astronomy of publications which shall give in a connected and digested form those results, experiences, and methods, which have been thoroughly elaborated by the Coast Survey, but are only accessible to foreign scientists through oral communication and the collation of the successive annual reports.

In my last report were contained the catalogues of circumpolar and time-stars prepared and adopted for the use of the telegraph parties. The former was based entirely upon Struve, but owing to my absence and consequent inability to bestow proper revision, some errors have crept into the printed table. During the present year eight other stars have been incorporated into the circumpolar catalogue and especial care devoted to its revision. I therefore take the liberty of appending it here also, and suggesting that it be printed with your annual report.

I remain, dear sir, very respectfully and faithfully yours,

B. A. GOULD, Jr.

Prof. A. D. Bache,
Superintendent U. S. Coast Survey.

LIST OF CIRCUMPOLAR STARS FOR LONGITUDE-OPERATIONS—1855.0.

No.	Names.	a	c	p	q	μ	a	b	c	d	δ
		h. m. s.	s.	s.	s.	s.					
1	21 Cassiopeiæ	0 36 9.09	+ 3.8138	+ 0.0791	+ 0.000026	— 0.015	9.3833 + 1.3 t	8.5849 — 1.0 t	0.5814 + 1.7 t	9.3666 + 1.4 t	74° 11′ 37″
2	Polaris	1 6 30.33	18.0464	6.0205	0.021158	+ 0.079	0.3981 + 14.3 t	9.8733 + 35.3 t	1.2564 + 29.6 t	0.3980 + 14.3 t	88 32 11
3	A. Cassiopeiæ	1 20 30.78	4.3035	0.0704	0.000015	+ 0.024	9.2525 + 0.6 t	8.8166 + 4.8 t	0.6338 + 1.4 t	9.2242 + 0.7 t	69 30 58
4	50 Cassiopeiæ	1 51 8.66	4.9583	0.0923	0.000019	— 0.010	9.2742 + 0.3 t	8.9959 + 4.1 t	0.6953 + 1.6 t	9.2517 + 0.4 t	71 42 59
5	ι Cassiopeiæ	2 17 10.68	4.8251	0.0651	0.000008	— 0.008	9.1446 + 0.2 t	8.9784 + 3.0 t	0.6835 + 1.2 t	9.1078 — 0.1 t	66 44 49
6	48 (Hev.) Cephei	3 2 5.43	7.2695	0.1751	+ 0.000021	+ 0.008	9.3237 — 1.0 t	9.3317 + 3.5 t	0.8615 + 2.1 t	9.3128 — 1.0 t	77 11 42
7	α Camelopardi	4 39 39.66	5.9042	0.0353	— 0.000011	— 0.010	8.7519 — 4.8 t	9.1889 + 1.0 t	0.7712 + 0.5 t	8.7129 — 4.7 t	66 5 21
8	Groomb. 966	5 20 22.03	7.9661	+ 0.0410	0.000043	+ 0.009	8.6449 — 14.4 t	9.4026 + 0.7 t	0.9012 + 0.5 t	8.6297 — 14.4 t	74 56 15
9	22 (Hev.) Camelopardi.	6 2 51.75	6.6217	— 0.0015	0.000022	+ 0.005	n7.3772 + 137.7 t	9.2768 — 0.1 t	0.8210 — 0.1 t	n7.3444 + 141.7 t	69 21 45
10	51 (Hev.) Cephei	6 31 5.91	30.6746	0.8044	0.004131	— 0.111	n9.2744 + 64.2 t	0.1392 — 2.7 t	1.4868 — 2.5 t	n9.2739 + 64.2 t	87 15 8
11	P. VII, 67	7 15 45.24	6.3247	0.0406	0.000015	+ 0.013	n8.7760 + 5.4 t	9.2406 — 1.1 t	0.8010 — 0.5 t	n8.7455 + 5.3 t	68 45 15
12	3 (Hev.) Ursæ Majoris.	7 58 19.83	6.0844	0.0591	0.000007	+ 0.011	n8.9609 + 2.8 t	9.2069 — 1.7 t	0.7842 — 0.8 t	n8.9308 + 2.7 t	68 53 40
13	o^2 Ursæ Majoris	8 57 34.28	5.4035	0.0670	— 0.000003	— 0.002	n9.0899 + 1.0 t	9.0991 — 2.4 t	0.7327 — 1.1 t	n9.0562 + 0.9 t	67 43 6
14	1 (Hev.) Draconis	9 16 2.31	9.2816	0.4061	+ 0.000135	— 0.004	n9.5561 — 0.8 t	9.4951 — 6.6 t	0.9676 — 3.8 t	n9.5518 + 0.2 t	81 57 38
15	24 Ursæ Majoris	9 21 35.07	5.4739	0.0859	0.000010	— 0.007	n9.1864 — 0.5 t	9.1041 — 3.0 t	0.7383 — 1.4 t	n9.1606 + 0.4 t	70 27 47
16	32 Ursæ Majoris	10 7 26.99	4.4768	0.0582	0.000009	— 0.015	n9.1571 — 0.1 t	8.8853 — 3.5 t	0.6510 — 1.2 t	n9.1172 — 0.2 t	65 49 46
17	9 (Hev.) Draconis	10 22 38.64	5.3597	0.1426	0.000046	+ 0.000	n9.4140 — 0.9 t	9.0694 — 5.3 t	0.7291 — 2.3 t	n9.4017 — 0.9 t	76 27 29
18	λ Draconis	11 22 44.74	3.6706	0.0569	0.000016	— 0.008	n9.2868 — 0.9 t	8.5017 — 8.3 t	0.5647 — 1.3 t	n9.2602 — 1.1 t	70 7 50
19	4 (Hev.) Draconis	12 5 21.40	2.9194	0.0645	0.000032	+ 0.007	n9.5212 — 2.0 t	n7.8898 + 35.6 t	0.4654 — 2.0 t	n9.5123 — 2.1 t	78 25 20
20	κ Draconis	12 27 16.12	2.6215	— 0.0279	+ 0.000009	— 0.013	n9.2992 — 1.3 t	n8.3768 + 5.7 t	0.4185 — 0.9 t	n9.2737 — 1.3 t	70 35 16
21	32 (Hev.) Camelop. fol.	12 48 7.10	0.3279	+ 0.1160	— 0.000108	— 0.021	n9.8098 — 4.1 t	n9.1384 + 3.6 t	9.5158 + 29.2 t	n9.8076 — 4.2 t	84 12 4
22	α Draconis	14 0 27.90	+ 1.6286	0.0024	0.000000	— 0.008	n9.1361 — 1.1 t	n8.8996 + 0.1 t	0.2118 + 0.1 t	n9.0936 — 1.2 t	65 4 10
23	5 Ursæ Minoris	14 27 53.20	— 0.2370	0.0615	0.000019	+ 0.003	n9.3532 — 1.3 t	n9.2299 — 1.5 t	n9.3748 — 22.9 t	n9.3408 — 1.4 t	76 20 26
24	β Ursæ Minoris	14 51 10.50	0.2595	0.0519	0.000013	— 0.006	n9.2694 — 1.0 t	n9.2359 — 1.2 t	n9.4141 — 31.2 t	n9.2539 — 2.2 t	74 44 53
25	γ^2 Ursæ Minoris	15 20 59.46	0.1589	0.0380	0.000007	— 0.003	n9.1480 — 0.8 t	n9.2280 — 0.9 t	n9.2012 — 21.2 t	n9.1271 — 0.9 t	72 21 0
26	ζ Ursæ Minoris	15 49 19.99	— 2.3340	0.1026	0.000017	+ 0.014	n9.2468 — 0.2 t	n9.4398 — 1.8 t	n0.3681 — 3.8 t	n9.2376 — 0.0 t	78 14 18
27	Groomb. 2320	16 5 56.64	+ 0.1356	0.0206	0.000002	— 0.010	n8.9328 — 0.6 t	n9.1978 — 0.5 t	9.1322 + 33.5 t	n8.9006 — 1.7 t	68 11 33
28	15 Draconis	16 28 17.33	— 0.1498	0.0207	— 0.000002	+ 0.004	n8.8618 + 0.7 t	n9.2354 — 0.4 t	n9.1755 — 34.8 t	n8.8322 — 0.4 t	69 4 53
29	ε Ursæ Minoris	17 0 59.21	6.4519	0.1503	+ 0.000060	+ 0.009	n9.1011 + 7.3 t	n9.6805 — 1.4 t	n0.8097 — 2.1 t	n9.0971 + 7.2 t	82 16 7
30	ω Draconis	17 37 48.30	0.3634	0.0069	0.000000	+ 0.005	n8.2515 + 1.1 t	n9.2641 — 0.1 t	n9.5604 — 1.7 t	n8.2212 + 1.0 t	68 49 26
31	ψ Draconis, (pr.)	17 44 31.45	1.0878	+ 0.0077	0.000002	— 0.009	n8.1682 + 5.0 t	n9.3381 — 0.1 t	n0.0366 — 0.7 t	n8.1470 + 4.9 t	72 13 8
32	δ Ursæ Minoris	18 19 7.09	19.3529	— 0.2796	0.001564	+ 0.033	8.9715 — 79.6 t	n0.0492 + 11.1 t	n1.2867 + 1.2 t	8.9708 — 79.7 t	86 35 59
33	50 Draconis	18 51 1.48	— 1.8846	0.0273	+ 0.000003	— 0.014	8.7623 — 22.3 t	n9.4075 + 0.4 t	n0.2752 + 1.3 t	8.7477 — 22.2 t	75 15 33
34	δ Draconis	19 12 30.65	+ 0.0182	0.0113	— 0.000001	+ 0.020	8.7323 + 0.3 t	n9.2173 + 0.3 t	8.2610 — 9.0 t	8.6976 — 0.6 t	67 24 23
35	τ Draconis	19 18 18.97	— 1.0704	0.0281	0.000001	— 0.034	8.8852 — 0.4 t	n9.3342 + 0.6 t	n0.0295 + 2.3 t	8.8660 — 0.4 t	73 5 3
36	ε Draconis	19 48 38.56	0.1786	0.0218	0.000002	+ 0.013	8.9472 + 0.4 t	n9.2370 + 0.6 t	n9.2519 + 10.5 t	8.9199 + 0.5 t	69 53 53
37	λ Ursæ Minoris	20 8 30.89	54.6215	14.7860	0.007730	— 0.051	0.2569 — 18.3 t	n0.4590 + 21.8 t	n1.7374 + 23.0 t	0.2568 — 18.3 t	88 52 32
38	κ Cephei	20 13 40.98	1.8691	0.0817	0.000014	— 0.007	9.2219 + 0.1 t	n9.4024 + 1.4 t	n0.2716 + 3.8 t	9.2111 — 0.2 t	77 16 22
39	Groomb. 3241	20 30 35.82	0.1941	0.0332	0.000006	— 0.012	9.1208 + 0.7 t	n9.2335 + 0.8 t	n9.2880 + 14.7 t	9.0991 + 0.8 t	72 2 25
40	T. Y. 1879	20 54 1.33	— 2.4316	0.1518	0.000048	— 0.010	9.4224 + 0.8 t	n9.4450 + 2.4 t	n0.3859 + 5.4 t	9.4157 + 0.9 t	80 0 22
41	β Cephei	21 26 46.36	+ 0.8040	0.0170	0.000004	+ 0.001	9.1830 + 1.1 t	n9.0806 + 0.6 t	9.9053 — 1.9 t	9.1558 + 1.2 t	69 55 28
42	11 Cephei	21 39 47.02	0.8859	0.0164	0.000004	+ 0.026	9.2166 + 1.2 t	n9.0627 + 0.6 t	9.9474 — 1.6 t	9.1913 + 1.3 t	70 38 39
43	79 Draconis	21 51 4.00	0.7370	0.0230	0.000006	+ 0.009	9.2857 + 1.3 t	n9.0854 + 0.8 t	9.8675 — 4.2 t	9.2663 + 1.9 t	73 0 56
44	Cephei, 226 Bode	22 29 42.64	1.0902	— 0.0164	— 0.000006	— 0.007	9.3901 + 1.7 t	n9.0089 + 0.7 t	0.0375 — 1.3 t	9.3760 + 1.8 t	75 28 49
45	ι Cephei	22 41 31.67	2.1257	+ 0.0110	+ 0.000003	— 0.013	9.1812 + 1.1 t	n8.7149 — 1.1 t	0.3275 + 0.5 t	9.1400 + 1.3 t	65 26 19
46	ο Cephei	23 12 41.54	2.4161	0.0198	0.000005	+ 0.016	9.2284 + 1.2 t	n8.5495 — 2.7 t	0.3831 + 0.6 t	9.1935 + 1.3 t	67 19 8
47	γ Cephei	23 33 25.95	2.4113	0.0365	0.000016	— 0.021	9.4631 + 1.9 t	n8.5293 — 4.9 t	0.3823 + 1.3 t	9.4515 + 2.0 t	76 49 22
48	Groomb. 4163	23 47 49.62	+ 2.8307	+ 0.0434	+ 0.000015	— 0.002	9.3726 + 1.5 t	n8.0980 — 15.7 t	0.4519 + 1.3 t	9.3546 + 1.5 t	73 36 16

For any time, we have the mean right-ascension $= a + (c + \mu)\,t + \frac{1}{100}\,pt^2 + \frac{1}{100}\,qt^3$, ------ t denoting the number of years elapsed since 1855.0.

APPENDIX No. 21.

Report to the Superintendent by Assistant George W. Dean on details of the method adopted for telegraphic operations to determine difference of longitude, with descriptions of the instruments and means employed.

MACON, GEORGIA, *April*, 1856.

DEAR SIR: In accordance with your request I respectfully submit the following report upon the method of determining differences of longitude by means of the electro-magnetic telegraph as at present pursued in the United States Coast Survey operations.

To make the subject more easily understood by those who have not seen these experiments, it may be well first to present a general recapitulation of the instruments and equipments required by each field party, and afterwards a detailed description of such of them as will make it intelligible to all.

Each party is furnished with a forty-six inch transit, an astronomical clock, a sidereal chronometer, a Morse telegraph register, a chronographic register, a Grove's battery of forty-five cups, and a self-sustaining battery, either Mathiot's, Smee's, or Daniel's, which is used in the local circuit.

The stations are generally selected from two to six hundred miles apart, as circumstances may require, though experiments have been successfully made between stations a thousand miles distant from each other. Temporary field observatories are built in the most simple style, affording the greatest convenience and best protection to the instruments at least expense; the cost varying from fifty to one hundred dollars, according to the locality. The sites for the observatories are selected with special reference to the greatest stability of the instruments when once adjusted, and a clear sweep of the heavens from north to south. The transit instrument is always adjusted upon a granite or marble block, about five feet in length, three in width, and one foot in thickness. This block is sunk into sand about two and a half feet, and when necessary (as in a clay soil) it is protected from lateral pressure by a curb or box, a foot greater in both dimensions, placed around it. In case the location is wet or marshy, a grillage, from twelve to fifteen feet square, is made of six-inch planks, arranged transversely and strongly spiked together. This is placed from two to three feet below the ground surface, and upon it the stone piers are adjusted, the whole being enclosed in a strong crib, flush with the ground, and filled with sand, leaving a ditch around to prevent, as far as possible, any movement of the foundation. Figure 1, Sketch No. 66, is intended to represent a transit pier adjusted in the field.

The astronomical clock is fastened to a granite or marble pier, of suitable size, when one can conveniently be obtained; but this is not absolutely necessary, as well-seasoned, hard, or white pine timber has been found to answer every purpose, when properly secured in the ground.

The observatory being ready for occupation, a single day is sufficient for the practised observer to set up his transit and clock, and one clear night will enable him to adjust his transit in the meridian, and obtain a reliable clock correction.

It sometimes happens that neither the approximate latitude nor longitude is known before reaching the station; but this is of little consequence to the practical astronomer, as he can soon determine the approximate latitude sufficiently near for his immediate purposes by measuring the zenith distance of a few of the principal stars which pass near his zenith, by means of the "finders" upon his telescope. An approximate latitude being thus determined, (within a minute or two of arc,) he is prepared to determine an approximate clock correction, by observing stars as near to the zenith as practicable, both north and south. This done, he is ready to place the telescope in the meridian, by directing it upon any of the circumpolar stars the time of culmination of which may be most convenient. After the instrument is adjusted in the meridian, the cast-iron frame, or stand which supports the telescope, is firmly secured to the top of the stone pier with plaster of Paris prepared with water in the form of thick cream, and poured into the holes made in the base of the stand for this purpose.

Transit Instrument.—The transits used by the Coast Survey parties were made in the most approved manner by Troughton & Simms, of London; the focal length of each is forty-six inches, with an aperture of two and three-quarter inches. Their magnifying power in use is about one hundred.

Before commencing the observations, the riding level is carefully adjusted. The telescope is then set to a stellar focus by directing it upon a planet or star, or any distant terrestrial object. The parallax of the eye-piece, the verticality of the threads, and the collimation, are carefully examined and adjustment made, if necessary. The manner of making these adjustments is supposed to be already familiar, and need not be repeated here.

For telegraphic purposes, the diaphragm is composed of twenty-five threads, arranged in five groups, as in Figure 2, Sketch No. 66, which represents the field of the telescope. The equatorial intervals between the threads, which form a group or tally, as it is called; or, in other words, the time required by a star upon the equator to pass from one thread to another, is about two and a half seconds of time. The intervals between the tallies are twice as large as the intervals between the threads forming a tally. This brief description of the transit instrument will perhaps suffice for present purposes, as the reader is supposed to be already familiar with its construction.

Astronomical Clock.—The value of the astronomical clock is determined by the amount of the variation in its daily rate, after having been once adjusted and regulated with great care. It differs from the common clock chiefly in the construction of its escapement wheel and the pallets that check the movement of the wheel, in connection with the compensating pendulum, by which the centre of oscillation, or centre of gravity, is kept at the same distance from the point of suspension under all temperatures. The escapement most generally used in astronomical clocks is known as the "*dead beat*" escapement, from its peculiar motion, which allows the second hand to move forward by jerks. These occur at the extremes of the arc of the pendulum vibration. The compensating pendulums are generally known as the "*mercurial*" and the "*gridiron.*" The former is constructed of a flat steel rod about half an inch wide, one eighth of an inch in thickness, and between thirty-five and thirty-six inches in length. Upon the bottom of this slides a steel stirrup, of sufficient dimensions to sustain a glass or iron mercurial jar, two inches in diameter and eight inches in height. Figure 3, Sketch No. 66, is intended to represent the form of the mercurial pendulum; and also the ingenious contrivance for conducting the galvanic circuit through the clock, as devised and made by Joseph Saxton, Esq., assistant in charge of the Office of Weights and Measures of the United States. P represents the steel pendulum rod; S is the steel stirrup which slides freely upon the bottom of the pendulum rod, to be elevated or depressed at pleasure by turning the milled head screw *a*, and M represents the iron mercurial jar, which rests in the stirrup. Glass jars have heretofore been used for the purpose, but in a field instrument, where much risk must always attend its transportation, the observers had often felt the want of something more safe and convenient for transporting so large a quantity of mercury than a glass jar or bottle. Accordingly Mr. Saxton (at my request) last year made an iron jar of the same capacity as the glass one heretofore used. Its dimensions are about one and a half inch in diameter, and seven and a half inches in height. It is closed at the top by a small screw, which secures the mercury in transportation. In this form of pendulum, the principle of compensation consists in having a column of mercury just sufficient to counteract the changes in the length of the steel rod, arising from variation in the temperature. On referring to the drawing, it will be readily understood that a rising temperature will lengthen the steel rod P, and cause the centre of oscillation to fall lower from the point of suspension; the mercury in the jar M, on the contrary, will, from the same cause, expand upwards, thereby diminishing the distance between the centre of oscillation and point of suspension. The exact quantity of mercury necessary for adjusting the compensation can only be ascertained by experiment. As a general rule, however, a column of mercury between six and seven inches in height will be found nearly correct.

Perhaps a clear idea of Mr. Saxton's ingenious contrivance for connecting the galvanic circuit through the Hardy clock will be more readily obtained from the drawing B. Figure 3, Sketch No. 66, is a brass plate, fourteen inches in length, and one and a half in width, and one fourth of an inch in thickness. This is suspended on the back of the clock case by means of two steel rods *s*, *s'*, of the same dimensions as the pendulum rod before described, and from points in a horizontal plane passing through the point of suspension of the pendulum. Plate B is kept in position in the clock case by the screws *b* and *b'*, which are so adjusted as to allow the plate to move freely in a vertical plane, whenever a change of temperature may contract or expand the steel rods *s*, *s'*. The object of this compensating arrangement is to keep the little platinum tilt-hammer (to be presently described) at a proportional distance from the point of suspension of the pendulum at all temperatures. I in the figure represents an ivory plate fixed upon the brass arm A, projecting at a right angle from the plate B. The ivory insulates the galvanic circuit from the brass work of the clock, and on this plate the platinum tilt-hammer is delicately adjusted in a little silver frame. By means of the screw *x*, represented in the figure as passing through the lower part of the frame, and pressing against the end of the ivory plate, the tilt-hammer may be adjusted in a horizontal position, so as to make the highest point fall directly below the centre of the metallic pin, which projects from the small ivory slide *c*, attached to the pendulum rod. The opposite end of the tilt-hammer rests upon a small brass standard, plated with platinum, and connected with the brass arm A. This platinum plate being insulated from the frame which supports the tilt-hammer, the galvanic circuit through the clock is completed only when the end of the tilt-hammer is in contact with the brass standard.

The ivory plate *c*, upon the pendulum rod, is adjustible in a vertical plane, and after the clock has been firmly secured upon its pier, the metallic pin upon the ivory plate is adjusted so as to press upon the apex of the tilt-hammer just sufficient to break the contact formed by the opposite end of the hammer resting upon the brass standard. The copper wires *w* and *w'* form a part of the galvanic circuit. When *w* is connected with the framework which supports the tilt-hammer, and *w'* with the brass plate B, and the end of the tilt-hammer rests upon the brass standard, the circuit is closed, and the galvanic circuit passes freely from *w* to *w'*. This is the case at all times when the battery is in action, except the instant that the pendulum reaches the centre of its oscillation, when the metallic pin on the rod touches the apex of the hammer, and breaks the contact by lifting the opposite end of the hammer. Platinum being one of the best conductors for the galvanic current, the slightest contact between two pieces of this metal forms a very perfect connection of the circuit; hence the simple pressure of the end of the little tilt-hammer upon a platinum plate is sufficient to close a galvanic circuit of many hundred miles in length. Experiments were made by the late Professor Sears C. Walker upon a circuit of more than two thousand miles in length.

Almost immediately after the circuit is broken by the clock, the end of the tilt-hammer falls upon the platinum plate, and the circuit remains closed until the pendulum reaches the centre of the next oscillation, when it is again broken. From this brief description, the mechanical arrangement by which the clock is made to record its own time upon the common telegraphic register, or, in a more perfect and beautiful manner, upon a chronographic register, designed expressly for this purpose, may perhaps be understood. Before proceeding to describe the recording apparatus, I must refer to Figure 6, (sketch No. 66,) which is drawn from a specimen of the chronographic recording in Bond's Chronographic Register. It will be observed, that at the beginning of each minute the second mark is omitted upon the sheet, or, in other words, the circuit is not broken by the clock. It will further be noticed, that at the beginning of each five minutes *two* second marks are omitted. This is designed for the purpose of checking the time, as noted by the recorder in the observatory, and for facilitating the reading of the sheets when posting the observations in a book prepared for that purpose.

The simple and beautiful contrivance for obtaining this result was designed and made by Mr. Saxton. Figure 4 is intended to represent the manner of completing the galvanic circuit through the clock at the beginning of each minute. B and B′ are brass plates, which are insulated from the brass-work of the clock by intervening thin plates of ivory (not represented in the figure.) The wires *d* and *d′* connect the plates B and B′ with the brass plate B, shown in Figure 3; *a* and *a′* are platinum pins, which project about a quarter of an inch from plate B; *l* and *l′* are light platinum bars, turning freely upon platinum axes at *b* and *b′*. On the bar *l′*, the platinum pin *c′* rests upon the periphery of a light brass wheel, which is firmly fixed upon the shaft of the second hand. The little notch on the circumference of the wheel is coincident with the position of the second hand when indicating sixty seconds upon the face of the clock. In the figure the second hand is supposed to indicate fifty-nine seconds upon the clock; at the next vibration of the pendulum, it moves forward to sixty seconds, the projecting pin on the bar *l′* slips into the notch upon the circumference of the wheel A′, and the end of the bar falls upon the platinum projection *a′*, when the galvanic current will pass through the clock, as indicated by the arrows *e e′*. At the next vibration of the pendulum, the wheel A′ moves forward in the direction indicated by the arrows, throwing the small pin out of the notch in the periphery of the wheel, and thereby breaking the circuit at *a′*. The wheel A is of the same diameter as A′, and is fixed upon the shaft of the minute hand. It has twelve notches equidistant upon its circumference, one of which is coincident with the position of the minute hand when indicating an even five minutes on the face of the clock. The bar *l* is similar to *l′*, and operates in the same manner. At every five minute mark, indicated by the hand upon the dial, the pin *c* on bar *l* slips into one of the notches, thus allowing the end of bar *l* to touch the platinum projection on the plate B. The notches upon this wheel are so formed as to allow the pendulum to make two vibrations before the pin *c* is again thrown upon the circumference of the wheel, which breaks the circuit at *a*. It will be perceived from the drawing that the galvanic circuit is connected through the clock whenever either of the bars *l* or *l′* is allowed to touch the platinum projections *a* or *a′*, although the circuit through the tilt-hammer continues to be raised at each vibration of the pendulum.

Chronographic registers.—The register invented and made by Messrs. Bond, of Boston, has a cylinder eleven and a half inches in length, and nineteen inches in circumference. Its motion is regulated by a centrifugal fly-regulator, similar to those used upon equatorial instruments, in connection with a pendulum adjusted to vibrate half seconds, and which allows the cylinder to revolve uniformly once a minute. The paper is conveniently secured upon the cylinder by spring clamps attached for that purpose. The cylinder is of such size as will admit of recording the observations made in two hours without raising the pen from the paper. Figure 6 (sketch No. 66) is a specimen of chronographic recording on Bond's Register. Figure 7 is a specimen of chronographic recording on Saxton's Register, the cylinder of which is eight inches in length and fifteen inches in circumference, adjusted to revolve twice a minute. Its motion is regulated by a combination of the crank with the vibration of two pendulums. It is hardly necessary here to give a detailed description of these instruments, as both may be easily understood from a slight inspection.

Batteries.—The Grove's battery, used in the main circuit in the Coast Survey experiments for determining differences of longitude, is the same as that generally employed in telegraph offices.

The Mathiot self-sustaining battery, which is sometimes used in the local circuit, has been found very convenient. An elaborate description of this battery, written by Mr. Mathiot, may be found in the Coast Survey Report for 1854. Appendix No. 56, page 193.

The improved Daniel's battery is of more recent date than either Groves' or Mathiot's, and a brief description of it here may be of interest.

Figure 5 (sketch No. 66) represents two jars of the Daniel's battery. C C are made of copper plate, about one-sixteenth of an inch in thickness, eight inches in depth, three and a half inches in diameter at the bottom and four at the top. P P are cylindrical porous jars, one-eighth of an inch in thickness, seven and a half inches in depth, and two inches in diameter. Z Z are zinc plates, which are suspended in water in the porous jars. To set the battery in action, the space between the porous and copper jar is filled with sulphate of copper, (blue vitriol,) and the porous jar is filled with fresh water. The zinc plates *require* no amalgamation, (but would thereby be more serviceable;) and as soon as the water filters through the porous jars sufficiently to saturate thoroughly the sulphate of copper, the galvanic action between the metals will take place when the poles of the battery are connected. It requires from one to two days for the sulphate of copper to become sufficiently saturated to produce a strong current; but a few drops of sulphuric acid, mixed with the water in each porous cup, will greatly facilitate its action. The porous cups are kept filled with pure water, and the copper jars are supplied with blue vitriol, from time to time, as circumstances may require.

When in good working condition, the intensity of the current from two jars of this battery is equal to the intensity of one cup of Groves'. The chief recommendation for this battery in field purposes consists in its portability, small original cost, and the economy in keeping it in action. During the three weeks which it has been used in the past season in the longitude experiments, its performance has been highly satisfactory, and on one occasion it continued to give a strong current for more than a month, requiring now and then the addition of a little water and sulphate of copper.

Having described the astronomical instruments and telegraph apparatus in as brief a manner as possible, I will endeavor to give a general description of the mode adopted in the Coast Survey for determining differences of longitude by means of the Electro Magnetic Telegraph. On reaching the stations, the difference of longitude of which is to be ascertained, each observer determines his local time as soon as practicable. This, we have before stated, can be easily accomplished in a single clear night. The local time being determined, the observers take their chronometers to their respective telegraph offices (when the approximate difference of longitude is not already known) and determine an approximate difference of longitude in the following manner. The observer at one office makes a single tap upon the operator's signal key at every ten seconds, as indicated by his chronometer, while the observer at the other office notes the time of the tap by his chronometer, in the same manner as if he were observing the transit of a star. Six or seven taps are sufficient to give a good approximate difference of longitude. After the signals are completed, each observer informs the other how much his chronometer is fast or slow of the true time, and from this data the difference of longitude is at once obtained. This determination seldom requires more than ten or fifteen minutes. It is proper here to remark, that the officers connected with the telegraph lines upon which these experiments have been made by the Coast Survey have always cheerfully extended every facility within their power.

As soon as an approximate difference of longitude is obtained, a set of stars is selected with much care from the British Association Catalogue, and arranged in such a manner that while one astronomer is observing a star, the other may be engaged in adjusting his instruments or looking after other matters in his observatory that may require attention. The following copy of a portion of the longitude star list, which was used in the Macon and Montgomery telegraph campaign of this season, will, perhaps, be sufficient to convey a clear idea of this part of the programme, without further explanation.

COAST SURVEY ASTRONOMICAL STATION AT MACON, GEORGIA.

List of stars arranged from the B.A.C. for determining the difference of longitude between Macon, Georgia, and Montgomery, Alabama, March, 1856.

Approximate latitude of station = 32° 50′.
Assumed difference of longitude between Macon and Montgomery, 10*m.* 43*s.*

No. of star, B.A.C.	Level or reverse.	Mag.	N. or S.	α	Δ	Lamp. West.	Lamp. East.	Macon—Montgomery. Time of transit.
				h. m. s.	° ′	° ′	° ′	*h. m. s.*
	Level							
3371		3	S.	9 44 33	63 19	83 51	6 09	9 55 16
3399		5½	N.	48 47	48 16	8 54	81 06	59 30
	Reverse							
3416		6	S.	9 52 42	57 22	89 48	0 12	10 03 25
	Level							
3466		6	N.	02 16	48 38	8 32	81 28	12 59
	Reverse							
3490		6	S.	10 06 48	57 49	89 21	0 39	10 17 31
3508		4½	S.	08 39	65 52	81 18	8 42	19 22
	Level and reverse							
3534		6	S.	10 14 05	74 18	72 52	17 08	10 24 48
	Level							
3602		5½	N.	23 40	56 53	0 17	89 43	34 23
	Reverse							
3625		5½	N.	10 28 04	52 56	4 14	85 46	10 38 47
	Level							
3671		5½	S.	35 36	66 04	81 06	8 54	46 19
	Reverse and level							
3742		4½	S.	10 47 48	64 29	82 41	7 19	10 58 31
3757		5½	N.	51 23	48 48	8 22	81 38	02 06
	Reverse							
3776		5	S.	10 54 38	69 03	78 07	11 53	11 05 21
3784		6	N.	56 29	50 59	6 11	83 49	07 12
	Level and reverse							
3851		4	S.	11 10 29	57 40	89 30	0 30	11 21 12
3869		6	S.	14 57	71 46	75 24	14 36	25 40
	Reverse							
3886		6	S.	11 18 06	72 45	74 25	15 35	11 28 49
	Level							
3919		6	S.	24 19	74 50	72 20	17 40	35 02
	Reverse							
3964		5½	S.	11 33 18	67 51	79 19	10 41	11 44 01
	Level							
3990		4	S.	40 33	68 59	78 11	11 49	51 16
	Reverse and level							
4056		6	S.	11 54 21	67 06	80 04	9 56	12 05 04
4072		4½	S.	57 53	80 28	66 42	23 18	08 36
	Reverse							
4106		6½	S.	12 03 27	61 55	85 14	4 45	12 14 10
	Level							
4128		6	N.	12 02	56 08	1 02	88 58	22 45
	Reverse							
4169		5	S.	12 15 16	63 21	83 49	6 11	12 25 59
4184		5	S.	17 05	65 16	81 54	8 06	27 48
	Level and reverse							
4223		5½	S.	12 23 49	64 38	82 32	7 28	12 34 32
	Level							
4248		6	S.	29 45	72 07	75 03	14 57	40 28
	Reverse and level							
4290		5	S.	12 39 26	72 38	74 32	15 28	12 50 09
4304		6	S.	42 15	61 40	85 30	4 30	52 58
	Reverse							
4351		4½	S.	12 51 47	71 49	75 21	14 39	13 02 30
	Level							
4384		5	N.	58 59	53 26	3 44	86 16	09 42
	Reverse							
4421		4½	S.	13 05 08	61 24	85 46	4 14	13 15 51
4433		5	N.	07 10	49 05	8 05	81 55	17 53
	Level, reverse, & level							

For determining the azimuth and collimation of the transit, and also the clock correction each night, those stars only, whose places have been most accurately determined, are used. For greater convenience to the observer, manuscript catalogues of the principal circumpolar and zenith stars have, with much care, been compiled from several of the most reliable authorities. (See Appendix No. 46, page 287, Coast Survey Report, 1855, and page 166 of this report.) At least six or eight zenith stars, with lamp east and west, in connection with at least two reversals of the telescope, upon two circumpolar stars, are carefully observed each night before commencing the exchange of star signals for differences of longitude. The reversal of the telescope upon the circumpolar stars is for the purpose of determining the collimation of the threads. The telescope is raised and lowered in its Y's, without risk of jar to the instrument, by means of a reversing apparatus attached for that purpose.

The telegraph lines are usually available for making these experiments after the regular business of the telegraph company is completed. The time varies from ten p. m. to two a. m., when the operators in their respective offices connect the main telegraph wire with the wires extending to the respective Coast Survey stations, thus placing only the Coast Survey apparatus in the galvanic circuit. As a general rule, on connecting the stations by telegraph, the platinum or negative pole of the battery at the eastern station is connected with the ground plate, and the zinc or positive pole is connected with the ground at the western station.

The ground plate consists of a copper plate, from twelve to sixteen inches square, to which a No. 10 or 12 copper wire is well soldered. This plate is buried from four to five feet below the surface of the ground, the copper wire being of sufficient length to connect with the battery. It is desirable that this plate should be sufficiently below the surface so as to be constantly kept in contact with moist earth, since the ground forms one half of the galvanic circuit in all telegraph operations. It is immaterial which pole of the battery connects with the ground, so long as the opposite pole of the second battery is also connected with it.

As soon as the galvanic circuit on the main line is completed, the astronomer at the eastern station connects his clock with the circuit, and at once prepares for exchanging star signals. When a star enters the field of his telescope, he makes it known to the observer at the western station by rapidly breaking the circuit, thus producing a rattle. Figure 2 (Sketch No. 66) represents the diaphragm of the field of the telescope. The instant that a star is bisected by one of the vertical threads, the observer breaks the circuit by a tap upon the key *k*, seen in Figure No. 1, (K.) In clear weather, each star is observed only upon the three middle tallies or fifteen threads. In cloudy weather, it is observed on any threads which may be practicable.

The discussion of the results from former experiments seem to indicate that it is better to observe the star only upon fifteen threads than upon the twenty-five, since the eye of the observer becomes rapidly fatigued by observing the smaller stars upon so many threads. Most of the stars which can be conveniently arranged for telegraphic signals are unfortunately of the smaller magnitudes.

As soon as the signal is given for observing, the Morse register at each station is set in motion, and the record of the observation is obtained on four different registers. We may here incidentally remark, that the time recorded upon the registers most distant from the station where the observation is made is not strictly identical with the time recorded at the station of observation. This we shall notice more particularly hereafter.

Upon the completion of an observation, the observer signifies it by a signal similar to the one made at the commencement.

Immediately after the observation upon the star is completed, the riding level is placed upon the pivots of the transit, and allowed to remain a sufficient time to obtain a correct reading; it is then reversed, and again adjusted upon the pivots, and a second reading taken. The inclination of the axis of the telescope is indicated by one-fourth of the difference between the sums of the east and west ends of the level readings. The object in reversing the level upon the transit axis is to eliminate, as far as possible, the errors arising from its own imperfect adjustment. As soon as the level readings are completed, the observer is prepared for a second star, due notice of which is given by a signal to the second station. On completing the observation upon the second star, the telescope is carefully reversed in its Y's, and adjusted for observing the two stars upon the longitude list which will next pass the meridian. By this time the star which was first observed at the eastern station will be near the meridian of the western; and as soon as it may be necessary, the astronomer at that station informs the other that an observation is to be made, by a succession of rapid taps upon his break-circuit key. While the observer at the western station is employed in reading the transit level, after his first observation, the astronomer at the eastern station may transmit the signals upon a third star; after which he will read his transit level, and the astronomer at the western station will observe a second star. In this manner the star signals are exchanged and recorded upon the two registers at each station, until ten or twelve stars have been satisfactorily observed by each observer, with the eastern clock in the circuit. This clock is then disconnected from the galvanic circuit, and the western clock substituted in its place; after which the star signals are continued (when practicable) until an equal number of stars have been satisfactorily observed on.

It will be understood from the foregoing that the observations made at each station are recorded by the same clock, and hence the resulting difference of longitude is entirely free from errors which may exist in the assumed places of the stars. I have before stated that a signal made at one station is not recorded upon the registers at both stations at the same instant of time. This arises from several causes, amongst which are the resistance to the galvanic current in passing from one station to the other, and the difference in the adjustment of the different magnets in connection with the defects in their construction. This part of the subject cannot well be explained without extending the report to a much greater length than desirable. In passing, however, I would remark that this difference of time is accurately determined from the experiments of each telegraphic campaign, and is applied as a correction to the observed difference of longitude. The late eminent American astronomer, Professor Sears C. Walker, who, from the commencement, conducted these experiments, and continued in charge of this department of the Coast Survey until his decease, designated this correction as "*wave time.*" From this digression we return to complete our description of a night's operations for determining the difference of longitude.

After signals have been satisfactorily exchanged, by observing from twenty to twenty-five stars, (an equal number with each clock,) which usually requires from two to three hours, the telegraph operators are relieved from duty, and the night's work at each station is completed by observing the same number of zenith and circumpolar stars, and in the same manner as before commencing the exchange of star signals.

A faithful record of the observations, and all remarks pertaining to them, is kept by the recorder in the observatory. He also informs the observer what star is next to be observed, its position, and the time it will pass the meridian. To facilitate this, a convenient programme is arranged for the recorder; but to guard against mistakes, it demands his most prompt and strict attention. The following abstract, taken from one of the field records, will best show the form of the journal kept in the observatory:

MACON, GA., *April* 18, 1856.

Exchange of star signals for difference of longitude. Eastern clock put in circuit.
Barometer reads 29.710 *in.*
Int. Temp. 61°.2.
Ext. Temp. 59°.0.

(W.) * 4290. My. recd. min. aft. rat. 50; min. bef. rat. 50. [Obs'n bad on Morse.]
Chronographic Reg. not stopped.

(W.) * 4351. Mc. Lp. E. min. aft. rat. 52; min. bef. rat. 52. [3 m. Ts.]
Chronographic Reg. not stopped.

(W.) * 4304. My. reced. min. aft. rat. 53 ; min. bef. rat. 54.
Level Lamp E. at 12*h*. 55*m*.
W. 54.0 E. 41.8
W. 39.8 E. 56.0
(W.) * 4384. Mc. Lp. E. min. aft. rat. 59 ; min. bef. rat. 59. [3 m. Ts.]
Reversed inst. to Lp. West.
* 4351. My. reced. min aft. rat. 03 ; min. bef. rat. 04. [First two tallies lost.]
Chronographic Reg. not stopped.
(W.) * 4421. Mc. Lp. W. min. aft. rat. 0.5 ; min. bef. rat. 05. [3 m. Ts.]
Chronographic Reg. not stopped.
(W.) * 4433. Mc. Lp. W. min. aft. rat. 07 ; min. bef. rat. 07. [3 m. Ts.]
Chronographic Reg. not stopped
(W.) * 4384. My. reced. min. aft. rat. 10 ; min. bef. rat. 10.
Level lamp W. at 13*h*. 10*m*.
W. 38.2 E. 58.0
W. 53.5 E. 43.7
Reversed instrument to Lp. East.
Level lamp east at 13*h*. 13*m*.
W. 53.8 E. 43.1
W. 40.3 E. 56.6
(W.) * 4421. My. reced. min. aft. rat. 16 ; min. bef. rat. 16.
Chronographic Reg. not stopped.
(W.) * 4433. My. reced. min. aft. rat. 18 ; min. bef. rat. 18.
(W.) * 4499. Mc. Lp. E. min. aft. rat. 21 ; min. bef. rat. 21. [3 m. Ts.]
Chronographic Reg. not stopped.
(Lost.) * 4513. Mc. Lp. E. Star not seen.
Reversed to lamp W.
(W.) * 4536. Mc. Lp. W. min. aft. rat. 28 ; min. bef. rat. 29. [3 m. Ts.]
(W.) * 4552. Mc. Lp. W. min. aft. rat. 31 ; min. bef. rat. 31. [3 m. Ts.]
Chronographic Register not stopped.
(W.) * 4499. My. reced. min. aft. rat. 32 ; min. bef. rat. 32. [Obs'n bad on Morse.]
Level Lp. W. at 34*m*.
W. 39.0 E. 58.8 { Barometer = 29.69
W. 53.7 E. 44.0 { Int. Temp. = 60.8
Reversed instrument to Lp. East.
(Lost.) * 4513. My. Star not received.
(W.) * 4536. My. reced. min. aft. rat. 39 ; min. bef. rat. 39.
Chronographic Reg. not stopped.
* 4597. Mc. Lp. E. min. aft. rat. 40 ; min. bef. rat. 40. [3 m. Ts.]

Note.—The station where the observation is made, together with the position of the lamp, are both marked on the Morse fillet, as well as in the record. Therefore the abbreviation "Mc." and "My." before a star denotes respectively Macon and Montgomery. "W.," on the margin, signifies that the observation was well recorded in the registers. "Lp. E." and "W." signifies the position of the illuminated end of instrument, whether east or west. The characters "min. aft. rat." and "min. bef. rat." signify the minute by the clock *after* and *before* the rattle of the break-circuit key, at the beginning and end of each observation.

In order to guard against mistake, and to distinguish, in reducing the work, all the observations made for determining the instrumental or personal corrections are recorded in red ink, while the star signals for determining the difference of longitude are recorded in black upon the chronographic sheets.

Reading off the Chronographic Sheets.—As soon as practicable after the observations have been made, the chronographic sheets are carefully read off, by means of glass scales constructed for this purpose, and the readings posted in a book arranged in the following form:

Date	April 8th.	Mean of tallies.	April 8th.	Mean of tallies.	April 8th.	Mean of tallies.
Lamp	West.		West.		West.	
Star	θ Urs. Maj.		ε Leonis.		Regulus.	
Times of transit.	9 22 07.55 11.80 16.20 20.78 25.22		9 36 54.78 57.90 00.80 03.79 06.90		9 59 59.51 10 00 02.20 04.91 08.00 10.40	
	9 22 34.21 38.55 43.49 47.45 51.64		9 37 12.80 15.62 18.91 21.69 24.59		10 00 15.95 18.99 21.80 24.30 27.09	
	9 23 00.40 05.13 09.62 14.49 18.77		9 37 30.60 33.51 36.82 39.94 43.09		10 00 32.90 35.55 38.43 41.30 43.96	
	9 23 27.60 31.94 36.54 41.10 45.62		9 37 48.60 51.62 54.50 57.88 00.89		10 00 49.50 52.38 54.95 58.00 00.81	
	9 23 53.90 58.50 03.20 07.79 11.92		9 38 06.53 09.50 12.54 15.60 18.70		10 01 06.21 08.44 12.00 14.60 17.50	

Figures 9 and 10 (Sketch No. 66) are intended to represent the full size and exact form in which these glass scales are made. The fine lines upon the glass are produced by the action of fluospathic acid, (the particular process of which it is unnecessary here to describe,) and afterwards made to show more distinctly by means of printers' ink or other black compound. Both the convergent and parallel scales are used; each having its advantages, depending upon the kind of chronographic work to be read off. The scale with parallel lines is best adapted for reading off chronographic records when the second is represented by a line from three-fourths to an inch in length, as in the Saxton Register and Morse fillet; but when the second is represented by a line only half an inch or less, as is the case upon the spring-governor, the scale with convergent lines is preferable. One precaution is necessary to be carefully observed in using this scale, namely, to keep the lines which are marked upon the scale, exactly parallel with the lines upon the paper, otherwise erroneous readings are obtained, by not using proportional parts of the scale. These remarks will be understood by a reference to Figure 10, without further explanation. No such precaution is necessary in using the scale with the parallel lines, which give it a decided advantage over the convergent scale.

The breaking of the galvanic circuit by the clock, or the observer, as indicated by the chronographic method, is called the *electronic*, and the closing of the circuit is called the *electropic*.

In reading off, therefore, the electronics *only* are used, since they indicate the exact instant that the circuit was broken by the clock or observer. In Figure 6, (Sketch No. 66,) a and a' are the electronics of the clock breaks, and b is the electronic of the observer's break, or the instant at which an observation was made. Placing the glass scale upon the paper with the parallel lines upon it, coincident or parallel with the line $a\ a'$, and with the extreme convergent lines falling upon a and a', thus dividing it into ten equal parts, the proportional part of the line from a to b is at once obtained, by inspection, to the nearest hundredth of a second, and marked upon the sheet. In this manner all of the chronographic sheets are read off, the process being so simple as to require no further explanation.

For the purpose of obtaining, approximately, the transit and clock corrections, after each night's observations, the middle tally, upon which a few of the standard stars were observed, is read off to the nearest tenth of a second, by estimation, without using the glass scale. Six or seven stars are found to give results sufficiently accurate for executing all the field operations.

The following simple formulæ are used in the field reductions for obtaining the local time:

φ = approximate latitude of the station.
δ = declination of star.
α = right ascension of star.
m = mean of the threads.

$$A = \frac{\sin.\ (\varphi - \delta)}{\cos.\ \delta} = \text{star constant for azimuth correction.}$$

$$B = \frac{\cos.\ (\varphi - \delta)}{\cos.\ \delta} = \text{do level do}$$

$$C = \sec.\ \delta = \text{do collimation do}$$

A is positive except for stars between the zenith and pole.
B do do at lower culmination.
C do do do

180° — δ is used instead of δ when the star is below the pole.

a = azimuth correction in time.
b = level do do
c = collimation do do
t = observed time of transit corrected for level.
ω = approximate clock correction.
ω_0 = do do corrected for collimation.
Δt = do do corrected for collimation and azimuth.

The approximate clock and azimuth corrections are then computed as follows:

Assume an approximate clock correction θ and putting $\Delta\,\theta = \Delta t - \theta$ we have

$$\Sigma\,\Delta\,\theta + \Sigma\,A.\,a = \Sigma\,\omega'_0$$
$$\Sigma\,A.\,\Delta\,\theta + \Sigma\,A^2\,a = \Sigma\,A\,\omega'_0$$

from which $a.\ \Delta\,\theta$ and $\Delta\,t$ are deduced.

The accompanying example, taken from one of the volumes of the original field records, will serve to illustrate the method and form of the reductions:

Coast Survey, Astronomical Station, city of Macon, Georgia, March 15, 1856.

Star	δ Can. Maj.	δ Gem.	α^2 Gem.	α Can. Min.	β Gem.	ϕ Gem.
Lamp	East.	E.	W.	W.	W.	E.
Observer	E. Goodfellow.					
Mode	Chronographic.					
Levelling	W. 95.7 E. 99.7	W. 99.7 E. 97.3	W. 96.6 E. 103.0	---------------- ----------------	W. 98.7 E. 105.0	W. 103.4 E. 103.7
	4.0	2.4	6.4	----------------	6.3	0.3
	" s. =−1.00 =−0.07	" s. =+0.60 =+0.04	" s. =−1.60 =−0.11	" s. =−1.60 =−0.11	" s. =+1.57 =−0.10	" s. =−0.07 =−0.10
α	h. m. s. 7 2 32.80	7 11 32.08	7 25 25.45	7 31 46.49	7 36 30.99	7 44 41.82
Middle tally.	7 2 26.5 30.0 33.0 36.0 37.2	7 11 26.2 29.5 32.5 35.6 38.4	7 25 19.5 22.8 26.2 29.2 33.0	7 31 41.8 44.5 47.0 50.0 53.0	7 36 25.6 28.6 31.6 34.7 38.4	7 44 35.6 39.2 42.2 45.3 48.5
M.	7 2 32.94	7 11 32.44	7 25 26.14	7 31 47.26	7 36 31.78	7 44 42.16
A. B. C.	+ 0.95 + 0.57 + 1.11	+ 0.20 + 1.06 + 1.08	+ 0.01 + 1.18 + 1.18	+ 0.46 + 0.89 + 1.00	+ 0.09 + 1.13 + 1.14	+ 0.11 + 1.12 + 1.12
Bb. t. Cc.	− 0.04 7 2 32.90 + 0.21	+ 0.04 7 11 32.48 + 0.20	− 0.13 7 25 26.01 + 0.22	− 0.10 7 31 47.16 + 0.19	− 0.12 7 36 31.66 + 0.22	0.00 7 44 42.16 + 0.21
ω	− 0.10	− 0.40	− 0.56	− 0.67	− 0.67	− 0.34
ω_0	− 0.31	− 0.60	− 0.34	− 0.48	− 0.45	− 0.55

March 15, 1856.

κ Cephei.	L. C.
W.	E.
E. G.	
W. 101.5 E. 109.3	W. 105.6 E. 107.2
7.8	1.6
$= -1''.95 = -0^s.13$	$= -0''.40 = -0^s.03$
h. m. s. 8 13 34.50	
F 5 8 10 41.4 4 52.6 3 11 5.3 2 18.5 1 31.4 E 5 11 55.5 4 12 5.7 3 19.5 2 31.1 1 45.0 D 3 13 33.1	E 1 8 14 23.7 2 36.7 3 47.7 4 15 1.1 5 14.2 F 1 15 36.5 2 49.5 3 16 3.2 4 15.3 5 26.7
8 11 42.60	8 15 25.46
+ 4.26 − 1.56 − 4.54	
+ 0.20 8 11 42.80	+ 0.05 8 15 25.51
h. m. s. 8 13 34.15	
+	
+	0.35

For Collimation.

κ Cephei, L. C. $= Cc = -0.85s.$ $C = -4.54$ $c = +0.19s.$

Clock and azimuth correction.

Let $\theta = -0.40s.$

	ω_0	A	ω'_0	A^2	$A\omega'_0$	Aa	Δt
δ Canis Majoris, E	−0.31	+0.95	+0.09	0.90	+0.09	+0.19	−0.50
δ Gemin. ...... E.	−0.60	+0.20	−0.20	0.04	−0.04	+0.04	−0.64
α^2 Gemin. ...... W.	−0.34	+0.01	+0.06	0.00	0.00	+0.02	−0.36
α Canis Minoris, W.	−0.48	+0.46	−0.08	0.21	−0.04	+0.09	−0.57
β Gemin........ W.	−0.45	+0.09	−0.05	0.01	0.00	+0.02	−0.47
φ Gemin........ E.	−0.55	+0.11	−0.15	0.01	−0.02	+0.02	−0.57
κ Cephei.....W.E.	+0.35	+4.26	+0.75	18.15	+3.19	+0.85	−0.50
		+6.08	+0.42	+19.32	+3.18		−0.51

$7\,\Delta\theta + 6.08\,a = +0.42$ $\qquad$ $7\,\Delta\theta = 0.42 - 6.08\,a$

$6.08\,\Delta\theta + 19.32\,a = +3.18$ $\qquad$ $= -0.80$

0.845098 $\quad$ 0.783904 $\quad$ 9.623249 $\qquad$ $\Delta\theta = -0.11$

9.938806

0.722710 $\quad$ 9.562055 $\qquad$ $\Delta t = -0.51$

$6.08\,\Delta\theta + 5.28\,a = +0.36$

$14.04\,a = 2.82$

$a = +0.200$

While the observations at the stations are in progress, each observer determines the equatorial intervals of the threads in his transit by making at least thirty observations upon six or seven of the principal circumpolar stars. The inequalities of the transit pivots are also carefully determined by at least three series of levellings with the riding level.

This is done by noting the level when the illuminated end of the transit is towards the east, and then reversing the telescope to the west, and again noting the level, with the telescope adjusted at the same altitude in the opposite direction. The following copy of a series will better illustrate this:

COAST SURVEY STATION DE ROSSET, CITY OF WILMINGTON, N. C., JANUARY 23, 1856.

Observations for determining the inequality of the pivots of Coast Survey transit No. 8; *weather cool and pleasant, wind light from the northwest. Observer, George W. Dean.*

LAMP EAST, OBSERVER SOUTH OF INSTRUMENT.						LAMP WEST, OBSERVER NORTH OF INSTRUMENT.						
Time A. M.	Temp.	Altitude of the telescope.	Level.		West end of axis high in scale divis'n.	Time A. M.	Temp.	Altitude of the telescope.	Level.		West end of axis high in scale divis'n.	Correction of the illuminating end of axis in scale div'n.
			West.	East.					West.	East.		
h. m.	°	°				h. m.	°	°				
10. 05	29. 5	55	92. 2	75. 3		10. 07	29. 5	55	88. 0	78. 4		
			+ 89. 9	77. 5					88. 0	78. 0		
			182. 1	152. 8	7. 32				176. 0	156. 4	4. 90	+ 0. 60
10. 12	32. 0	50	89. 9	73. 5		10. 09	30. 5	50	87. 4	78. 0		
			87. 0	75. 9					87. 0	77. 5		
			176. 9	149. 4	6. 90				174. 4	155. 5	4. 72	+ 0. 54
10. 17	32. 0	45	86. 9	75. 3		10. 23	32. 5	45	83. 9	77. 0		
			89. 0	72. 6					87. 4	72. 8		
			175. 9	147. 9	7. 00				171. 3	149. 8	5. 37	+ 0. 41
10. 30	33. 5	40	88. 9	69. 2		10. 26	32. 5	40	87. 3	72. 3		
			83. 0	74. 2					82. 3	76. 5		
			171. 9	143. 4	7. 12				169. 6	148. 8	5. 20	+ 0. 48
10. 35	34. 0	35	83. 0	74. 0		10. 40	34. 0	35	81. 0	74. 5		
			87. 5	68. 8					85. 9	69. 5		
			170. 5	142. 8	6. 92				166. 9	144. 0	5. 72	+ 0. 30
10. 45	34. 5	30	87. 3	66. 0		10. 43	34. 5	30	85. 2	69. 0		
			80. 5	72. 4					80. 5	74. 0		
			167. 8	138. 4	7. 35				165. 7	143. 0	5. 67	+ 0. 42
10. 50	35. 0	25	80. 0	74. 5		10. 53	35. 0	25	79. 0	73. 5		
			86. 0	66. 0					85. 0	66. 5		
			166. 0	140. 5	6. 90				164. 0	140. 0	6. 00	+ 0. 22
11. 00	35. 5	20	86. 0	64. 0		10. 57	35. 0	20	84. 0	66. 7		
			78. 5	71. 4					78. 0	73. 0		
			164. 5	135. 4	7. 27				162. 0	139. 7	5. 57	+ 0. 42
11. 03	36. 0	15	78. 3	71. 0		11. 06	36. 0	15	77. 0	71. 5		
			85. 0	64. 0					83. 0	64. 6		
			163. 3	135. 0	7. 07				160. 0	136. 1	5. 98	+ 0. 27
11. 14	36. 0	10	84. 0	63. 0		11. 10	36. 0	10	83. 0	64. 5		
			77. 0	69. 0					76. 0	71. 0		
			161. 0	132. 0	7. 25				159. 0	135. 5	5. 87	+ 0. 34
11. 17	36. 5	5	76. 5	69. 5		11. 20	37. 0	5	75. 0	70. 2		
			83. 0	63. 0					81. 0	63. 8		
			159. 5	132. 5	6. 75				156. 0	134. 0	5. 50	+ 0. 31
11. 28	37. 0	0	82. 0	62. 0		11. 25	37. 0	0	80. 8	64. 0		
			75. 3	68. 0					74. 3	70. 2		
	34. 3		157. 3	130. 0	6. 82		34. 1		155. 1	134. 2	5. 22	+ 0. 40
											12)	4. 71

The correction to the illuminating end of the axis is equal to .... = + 0. 392
Scale division, 0. 392 × 0".99 = + 0".388 = + 0s.026.
Level marked "A," belonging to transit No. 8, was used in making these observations.
Value of one division of scale, = 0".99.

Personal equation.—It is a well established fact, that two observers are seldom found who observe the transit of a heavenly body at the same instant of time. This may arise from a single cause, or several causes combined; namely, difference in the sight or in the judgment, or that referable to the condition of the nervous system, or other peculiarities of the observers themselves, which makes it a changing and an uncertain element.

To ascertain this difference of time which may exist between the observers, from forty to fifty stars are observed upon alternate tallies by each observer, and the difference between the means of the observed times shows the magnitude of the personal equation. In order to eliminate this personal equation as far as practicable, in the final result for difference of longitude, the observers change places as soon as each campaign is half completed.

One hundred stars well exchanged are found to give a result for the difference of longitude, the probable error of which is less than the hundredth part of a second of time.

During the progress of the operations, experiments are made for determining the velocity of the galvanic current by using batteries of different powers, varying from ten to forty Grove's cups.

The latitude of each station is accurately determined by observations with the zenith telescope, at such times as the telegraph line may not be available for latitude observations.

The declination, dip of the needle, and other magnetic elements, are also determined at each station.

Very respectfully, your obedient servant,

GEO. W. DEAN, *Assistant.*

Prof. A. D. BACHE, *Superintendent U. S. Coast Survey.*

APPENDIX No. 22.

Extract from the report of Professor W. C. Bond, on moon culminations, observed for Coast Survey purposes, and relative to results of the chronometer expeditions between Cambridge and Liverpool, for difference of longitude.

CAMBRIDGE, *September* 19, 1856.

DEAR SIR: Since the 15th of September, 1855, I have obtained three occultations of stars, and one of the planet Jupiter by the moon, and forty-seven transits of the moon's limb with the requisite culminating stars, and a considerable number of transits of bright points on the moon's surface with the limb, for the purpose of further testing the relative value of the two methods of observation.

By the electric method we find no difficulty in obtaining several observations of bright points during the moon's passage, each more accurately than it is possible to observe the limb; some of these observations of bright points were made in correspondence with Dr. C. H. F. Peters, who operated in this vicinity at the "Clover Den" observatory; but not being provided with a suitable apparatus, or spring-governor, he was obliged to confine himself to a single point on the moon's surface, namely, *Messier* 1 —. These corresponding observations have been reduced by Dr. Peters, and afford additional evidence of the superior accuracy of this method over that of observing the moon's limb—a fact which I would again present to your consideration.

The transportation of chronometers, for the purpose of determining the difference of longitude between Liverpool and Cambridge, commenced on the sailing of the steamer America, June 5, 1855, and closed with the arrival of the steamer Africa, October 26, of the same year.

The previous trial of the chronometers, used for this expedition, commenced early in January, 1855, and the subsequent trials continued through the following winter. * * *

I remain, dear sir, yours faithfully,

W. C. BOND.

Prof. A. D. BACHE, *Superintendent U. S. Coast Survey.*

APPENDIX No. 23.

Letter to the Superintendent, transmitting report of G. P. Bond, Esq., on the results of the chronometric expedition of 1855, *for difference of longitude between Cambridge, Mass., and Liverpool.*

CAMBRIDGE, *May* 12, 1856.

DEAR SIR: I forward with this my report on the computation of the results of the chronometric expedition of 1855.

Respectfully and truly yours,

G. P. BOND.

Dr. A. D. BACHE,
Superintendent United States Coast Survey.

Report on the computation of the results of the chronometric expedition of 1855, *between Cambridge and Liverpool.*

The observations included in the discussion of the results of the chronometric expedition of 1855, between Cambridge and Liverpool, are characterized by several features in which they differ from those previously undertaken for the same object.

1. The observations of transits for clock error, and the comparisons of the chronometers employed in the reductions, have been made exclusively by the electro-magnetic method.

2. Appropriate means were employed to secure an entire elimination of personal equation.

3. In the general conduct of the expedition, attention has been specially directed to the effect upon the resulting longitudes of the temperature exposures to which the chronometers have been subjected.

The number of passages made across the Atlantic was six; and the total number of individual chronometers sent on the voyages, fifty-two.

As the methods of computation have been for the most part the same with those employed for the expeditions of 1849–'50–'51, and are fully explained in my final report upon the latter, it will be necessary to dwell only on those particulars in which the expedition of 1855 has differed from the preceding ones; these relate principally to the elimination of the effects of temperature.

The adoption of the electro-magnetic methods of observation and of comparison has contributed materially to the convenience both of the observer and of the computer. Besides this, it has furnished us with data for the errors on local time at both stations, and for the chronometric comparisons, by processes altogether independent of those before used.

All doubt respecting the possible influence of the personal equation of the observers upon the clock errors has been effectually removed by employing exclusively, for the epochs of the commencement and termination of each voyage, and for the determination of the shore rates, applied directly to the computation of longitudes, star transits taken at both stations by the same observer. The completeness of the series has allowed of the application of this principle to all the voyages.

The data for the discussion of the effects of temperature are as follows:

a. A record of the temperature exposure of the chronometers, from March to December, 1855, by the ordinary thermometers.

b. Comparisons of the chronometer, (Z,) from March to December, for determining the mean temperature of exposure of all the chronometers.

c. Trials of the thermometric chronometer (Z) in various exposures, in March, April, May, and December.

d. Experiments for ascertaining the time required for heating or cooling the balance of a chronometer when the temperature is changed.

e. Trial of all the chronometers in high, low, and medium temperatures, in April, May, November, and December.

The thermometric chronometer (Z) was made expressly for the expedition, and resembled in every respect an ordinary chronometer, excepting in the material of the arm and rim of the balance, which were of brass and uncompensated. The form, weight, and dimensions of the ordinary balance were purposely retained, in order that it might be subjected as nearly as possible to the same conditions for being affected by changes of temperature, resistance of the air, &c., with those of the usual construction.

Its indications of the mean temperature of exposure have proved incomparably more reliable than those obtained from the thermometers. The latter have, however, been constantly employed as checks upon the adopted temperatures, and to show the exposure of the other chronometers relatively to Z.

Experiments at exposures varying from 35° to 87°, showed for a range of nearly 20° above and below 60°, that the rate of Z altered *uniformly* with the temperature.

If θ° represents the mean temperature of exposure, and t the number of days from the epoch, March 25, 1855, the following expression gives the change of rate of Z in 24*h. m. s. t.*

$$\text{Change of rate of } Z = 6^s.512\ (69^\circ.75 - \theta^\circ) + 0^s.019\ t.$$

The last term is a correction for the acceleration of rate. A careful examination of the rate of Z during the continuance and at the close of the voyages, gives sufficient evidence of its regular performance during that interval, and that its indications of the mean temperature are entitled to entire confidence.

It was a matter of considerable importance to know how rapidly chronometers of the construction used upon the expedition, when submitted to a change of temperature, would acquire the rates appropriate to the new exposure. This is far too complicated a problem to be treated successfully in any other way than by direct experiment.

From its sensitiveness to the effects of these changes, the chronometer Z was very well suited to the trial. A representation of the rate at which the temperature of the balance accommodated itself to that of the surrounding air, when the exposure was changed suddenly from 40° to 75°, has been derived from a curve projected from comparisons made at intervals of five minutes for twelve consecutive hours, during which the chronometer, previously cooled to a temperature of 40°, was exposed at a uniform temperature of 75°. Other trials in smaller ranges of temperature gave similar results.

The curve thus projected indicates that a sensible equalization of temperatures is attained at the expiration of from five to six hours; more than one-half of the change being effected within the first two hours. The process of assimilation is dependent upon so great a variety of disturbing influences that it is not possible, in all cases, to determine with the requisite precision the temperature affecting the balance of the chronometer from that of the surrounding air, as given by ordinary thermometers, when the instruments are subject to the changes to which they must be peculiarly liable in their transportation between distant stations.

The results of the trials in different exposures to which the chronometers have been subjected during several months, have fully confirmed the generality of the law of variation of the rates by the disturbing influence of temperature adopted in my report on the expeditions of 1849–'50–'51. It has been applied to the correction of the longitudes in the following manner:

Employing the notation of my report of February 28, 1854, we have the expression—

$$(1) \qquad \frac{du}{dt} = a_\circ + \frac{k}{2}\left(\theta - \theta_\circ\right)^2$$

To represent the rate of a chronometer exposed at a temperature of θ, θ_0 being the temperature for which its balance has been compensated, and k being nearly constant when the range of temperature changes is small, a more comprehensive expression of this law may be deduced from the experiments made, but the above form is sufficiently accurate for all the purposes to which it has been applied.

If, moreover, we make

$$h = \int_0^t (\theta - \theta_0)^2 \, d\, t$$

$$\mathrm{H} = -\, h' + \tfrac{1}{2} \left[\frac{h}{t} + \frac{h''}{t''}\right] t' \text{ for the voyage from Liverpool to Cambridge—}$$

$$\mathrm{H} = h' - \tfrac{1}{2} \left[\frac{h}{t} + \frac{h''}{t''}\right] t' \text{ for the voyage from Cambridge to Liverpool—}$$

The temperature correction of the resulting longitude will be—

$$\delta_\theta \lambda = \frac{k}{2} \mathrm{H}.$$

The difficulties of the discussion consist in finding, first, the constants k and θ_0 peculiar to each chronometer, and secondly, the temperature exposures at sea and on shore, so as to afford the means of computing the numerical values of H. k and θ_0 have been ascertained by direct experiment. To obtain H, in default of any mathematical theory by which θ can be represented as a function of t, it will generally be necessary to resort to the method of quadratures.

The following is a convenient form for representing H in circumstances similar to the present:

Let θ_1, θ_1', θ_1'' be the mean value of θ for the interval t, t' and t''

ζ = the mean temperature on shore

ζ' = the mean temperature on the voyage

ζ'' = the mean of the sea and the shore temperatures

$$\zeta = \frac{\theta_1 + \theta_1''}{2}, \qquad \zeta' = \theta'_1, \qquad \zeta'' = \frac{\zeta + \zeta'}{2}$$

y = the probable value of $(\theta - \theta_1)$ for the interval t

y' = the probable value of $(\theta' - \theta_1')$ for the interval t'

y'' = the probable value of $(\theta'' - \theta_1'')$ for the interval t''

We shall then have

$$\frac{\mathrm{H}}{t'} = 2\, (\zeta - \zeta')\, (\zeta'' - \theta_0) + 1.10\, (y^2 - 2\, y'^2 + y''^2) + \tfrac{1}{4}\, (\theta_1 - \theta''_1)^2$$

$$\delta_\theta \lambda = \frac{k}{2} \mathrm{H}.$$

The attention which has been devoted to the care of the chronometers, in securing them from injurious exposures to changes of temperature, will best appear from the following numbers showing the values of ζ, ζ', ζ'', y, y', and y'', for the chronometer Z, but representing very nearly the condition of all the chronometers.

Voyage C_1	$\zeta = 63°.4$	$\zeta' = 59°.4$	$\zeta'' = 61°.4$	$y = \pm 1°.2$	$y' = \pm 0°.9$	$y'' = \pm 2°.1$
Voyage L_1	$\zeta = 66°.7$	$\zeta' = 66°.4$	$\zeta'' = 66°.6$	$y = \pm 1°.2$	$y' = \pm 2°.5$	$y'' = \pm 0°.6$
Voyage C_2	$\zeta = 66°.2$	$\zeta' = 67°.3$	$\zeta'' = 66°.8$	$y = \pm 0°.6$	$y' = \pm 2°.0$	$y'' = \pm 1°.1$
Voyage L_2	$\zeta = 65°.1$	$\zeta' = 64°.7$	$\zeta'' = 64°.9$	$y = \pm 1°.1$	$y' = \pm 2°.3$	$y'' = \pm 1°.7$
Voyage C_3	$\zeta = 61°.3$	$\zeta' = 61°.3$	$\zeta'' = 61°.3$	$y = \pm 1°.7$	$y' = \pm 1°.2$	$y'' = \pm 0°.8$
Voyage L_3	$\zeta = 58°.4$	$\zeta' = 60°.8$	$\zeta'' = 59°.6$	$y = \pm 0°.8$	$y' = \pm 2°.3$	$y'' = \pm 2°.3$

By the voyages C_1, C_2, &c., are represented the first, second, &c., voyages from Cambridge, and by L_1, L_2, &c., those from Liverpool.

Small corrections have been applied to these values of ζ, ζ', &c., to obtain those appropriate to each chronometer. The temperature corrections of longitude have then been computed and applied agreeably to the above formula. Notwithstanding the remarkable uniformity of exposure on most of the voyages, the effect of temperature has still been sensible. The largest correction that has been applied is $8^s.82$; the average correction, independent of signs, is $0^s.93$, the mean correction for all the chronometers and voyages, having regard both to signs and weights, is $= - 0^s.17$, with a probable error of $\pm 0^s.07$. The smallness of this value is owing to the very favorable circumstances, as regards exposure, under which the voyages have been made.

From the character of the data, there is reason to believe that the uncertainty of the temperature corrections depends chiefly on the two terms $(\zeta - \zeta')$ and $(\theta_1 - \theta_1'')$ used in computing H.

The effect of introducing corrections

$$\delta(\zeta - \zeta') \text{ and } \delta(\theta_1 - \theta_1'')$$

to be applied to the values actually used has been investigated with the following results:

For the voyage C_1 correction of the adopted longitude $= - \overset{s.}{0.52}\, \delta(\zeta - \zeta') + \overset{s.}{0.15}\, \delta(\theta_1 - \theta_1'')$
For the voyage C_2 correction of the adopted longitude $= - 0.18\, \delta(\zeta - \zeta') + 0.01\, \delta(\theta_1 - \theta_1'')$
For the voyage C_3 correction of the adopted longitude $= - 0.50\, \delta(\zeta - \zeta') + 0.10\, \delta(\theta_1 - \theta_1'')$

For the voyage L_1 correction of the adopted longitude $= + 0.19\, \delta(\zeta - \zeta') - 0.03\, \delta(\theta - \theta_1'')$
For the voyage L_2 correction of the adopted longitude $= + 0.27\, \delta(\zeta - \zeta') - 0.01\, \delta(\theta - \theta_1'')$
For the voyage L_3 correction of the adopted longitude $= + 0.71\, \delta(\zeta - \zeta') - 0.01\, \delta(\theta - \theta_1'')$
ζ and θ being expressed in degrees of Fahrenheit's scale.

The final longitude from the voyages of 1855, is as follows:

	h. m. s.	s.
Voyages from Liverpool to Cambridge	4 32 31.92	± 0.183
Voyages from Cambridge to Liverpool	4 32 31.75	± 0.188
Mean	4 32 31.84	± 0.186*
Liverpool west of Greenwich	+ 12 00.05	± 0.04
Personal equation	0.00	± 0.00†
Resulting longitude	4 44 31.89	± 0.19

The accompanying tables contain the individual results. The letters L_1, C_1, &c., are used to indicate the voyages from Liverpool and Cambridge respectively; k'' is the index of the irregularity of each chronometer; t' the length of the voyage in days; ϵ' the probable error arising from errors in the local time; ϵ'' is the probable error dependent on k'' and t'; H and k are the coefficients employed in determining the values of the temperature corrections $\delta_\theta \lambda$.

The experiments made to ascertain the effect of changes of atmospheric pressure, go to prove that their influence has not been sensible.

Respectfully submitted.

G. P. BOND.

Dr. A. D. BACHE, *Superintendent U. S. Coast Survey.*

* This probable error rests upon the assumption that there still remains a constant difference between the east and west voyages.

† Supposing the personal equation of the observer to have remained constant.

Longitudes by voyages of 1855.

No. of Chron.	Voyage.	$\lambda \pm \delta\lambda$.	Prob. error.	Weight	k''	t'	ϵ'	ϵ''	$\frac{H}{t'}$	$\frac{k}{2}$	$\delta_\theta \lambda$	Result. Long.
								s.		s.		
1	L_1	4 32 27.60	± 2.41	6	± 0.21	13.3	± 0.16	± 2.79	— 0.10	— 0.39	+ 0.52	28.12
	C_1	4 32 27.76	2.64	5	"	14.2	.11	2.98	— 0.40	— 0.39	+ 2.21	29.97
	L_2	4 32 22.16	1.97	9	"	11.4	.11	2.39	0.00	— 0.39	0.00	22.16
	C_2	4 32 30.28	1.97	9	"	11.2	.11	2.35	+ 0.29	— 0.39	— 1.27	29.01
	L_3	4 32 38.53	2.41	6	"	13.4	.27	2.81	— 0.08	— 0.39	+ 0.42	38.95
	C_3	4 32 29.93	± 2.08	8	"	12.1	.12	2.54	— 0.01	— 0.39	+ 0.05	29.98
° 2*a*	L_1	4 32 49.19	± 0.00	0	± 1.11	13.2	± 0.16	±14.65	+ 0.10	— 0.05	— 0.07	49.12
	C_1	4 32 39.71	0.00	0	1.11	14.2	.11	15.76	— 0.78	— 0.05	+ 0.55	40.26
	L_2	----------	-------	------	--------	------	.11	--------	--------	--------	--------	--------
	C_2	----------	-------	------	--------	------	.11	--------	--------	--------	--------	--------
	L_3	4 32 37.85	3.40	3	0.33	13.4	.27	4.42	— 0.47	— 0.05	+ 0.31	38.16
	C_3	4 32 27.29	± 3.40	3	0.33	12.1	.15	3.99	+ 0.02	— 0.05	— 0.01	27.28
2*b*	L_1	----------	-------	------	± 0.18	------	± 0.16	--------	--------	--------	--------	--------
	C_1	----------	-------	------	--------	------	.11	--------	--------	--------	--------	--------
	L_2	4 32 27.22	± 1.70	12	0.18	11.4	.12	2.05	— 2.14	—0.076	+ 1.85	29.07
	C_2	4 32 34.64	1.78	11	"	11.7	.15	2.11	— 0.53	—0.076	+ 0.47	35.11
	L_3	4 32 31.16	2.08	8	"	13.4	.27	2.41	+ 3.35	—0.076	— 3.42	27.74
	C_3	4 32 33.24	± 1.87	10	"	12.0	.12	2.16	+ 0.45	—0.076	— 0.41	32.83
3	L_1	4 32 47.00	± 3.40	3	± 0.33	13.2	± 0.16	± 4.36	+ 0.06	(°)	— 0.34	46.66
	C_1	4 32 31.21	4.17	2	"	14.2	.11	4.69	— 0.34	(°)	+ 2.06	33.27
	L_2	4 32 38.45	3.40	3	"	11.4	.11	3.76	+ 0.17	(°)	— 1.63	36.82
	C_2	4 32 30.85	2.94	4	"	11.2	.11	3.70	+ 0.06	(°)	— 0.29	30.56
	L_3	4 32 34.25	3.40	3	"	13.4	.27	4.42	— 0.20	(°)	+ 1.15	35.40
	C_3	4 32 32.55	± 3.40	3	"	11.9	.12	3.93	— 0.08	(°)	+ 0.41	32.96
4	L_1	4 32 37.45	± 2.64	5	± 0.24	13.2	± 0.16	± 3.17	+ 0.06	(°)	+ 0.48	37.93
	C_1	4 32 22.68	2.94	4	"	14.2	.11	3.40	— 0.34	(°)	— 2.91	29.77
	L_2	4 32 35.49	2.22	7	"	11.4	.11	2.74	+ 0.17	(°)	+ 1.20	36.69
	C_2	4 32 29.75	2.22	7	"	11.2	.11	2.69	+ 0.06	(°)	+ 0.42	30.17
	L_3	4 32 36.15	2.64	5	"	13.4	.27	3.22	— 0.19	(°)	— 1.58	34.57
	C_3	4 32 31.14	± 2.41	6	"	11.9	.12	2.86	— 0.08	--------	— 0.59	30.55
5	L_1	4 32 26.54	± 1.97	9	± 0.18	13.2	± 0.16	± 2.38	— 0.32	— 0.20	+ 0.84	27.38
	C_1	4 32 34.21	2.22	7	"	14.2	.11	2.56	+ 1.11	— 0.20	— 3.12	31.09
	L_2	4 32 29.69	1.70	12	"	11.4	.11	2.05	— 0.58	— 0.20	+ 1.32	31.01
	C_2	4 32 31.52	1.70	12	"	11.2	.11	2.02	— 0.06	— 0.20	+ 0.13	31.65
	L_3	4 32 39.31	2.08	8	"	13.4	.27	2.41	+ 0.76	— 0.20	— 2.04	37.27
	C_3	4 32 37.57	± 1.78	11	"	11.9	0.12	2.14	+ 0.31	— 0.20	— 0.74	36.83
6	L_1	4 32 30.32	± 1.70	12	± 0.15	13.2	± 0.16	± 1.98	— 0.27	— 0.21	+ 0.75	31.07
	C_1	4 32 38.71	1.78	11	"	14.2	.11	2.13	+ 0.92	— 0.21	— 2.74	35.97
	L_2	4 32 31.62	1.43	17	"	11.4	.11	1.71	— 0.48	— 0.21	+ 1.15	32.77
	C_2	4 32 28.39	1.43	17	"	11.2	.11	1.68	— 0.03	— 0.21	+ 0.07	28.46
	L_3	4 32 33.42	1.70	12	"	13.4	.27	2.01	+ 0.64	— 0.21	— 1.80	31.62
	C_3	4 32 32.06	± 1.52	15	"	11.9	.12	1.78	+ 0.23	— 0.21	— 0.57	31.49
7	L_1	4 32 43.21	± 2.64	5	± 0.25	13.2	± 0.16	± 3.30	— 0.03	— 0.38	+ 0.15	43.36
	C_1	4 32 30.14	2.94	4	"	14.1	.11	3.52	— 0.52	— 0.38	+ 2.79	32.93
	L_2	4 32 36.59	2.41	6	"	11.4	.11	2.85	+ 0.21	— 0.38	— 0.91	35.68
	C_2	4 32 30.61	2.41	6	"	11.2	.11	2.80	+ 0.14	— 0.38	— 0.60	30.01
	L_3	4 32 32.51	2.64	5	"	13.4	.27	3.35	— 0.18	— 0.38	+ 0.92	33.43
	C_3	4 32 30.74	± 2.64	5	"	11.9	.12	2.97	— 0.15	— 0.38	+ 0.68	31.42
8	L_1	4 32 33.65	± 1.70	12	± 0.15	13.3	± 0.16	± 1.99	— 0.04	— 0.25	+ 0.13	33.78
	C_1	4 32 29.01	1.78	11	"	14.2	.11	2.13	— 0.42	— 0.25	+ 0.49	30.50
	L_2	4 32 32.36	1.43	17	"	11.4	.11	1.71	+ 0.21	— 0.25	— 0.60	31.76
	C_2	4 32 32.32	1.43	17	"	11.3	.11	1.69	+ 0.12	— 0.25	— 0.34	31.98
	L_3	4 32 30.40	1.70	12	"	13.4	.27	2.01	— 0.10	— 0.25	+ 0.33	30.73
	C_3	4 32 31.60	± 1.52	15	"	11.9	.12	1.78	— 0.11	— 0.25	+ 0.33	31.93

° The error of 2*a* was, by some accident, altered by several minutes at Liverpool between the voyages C_1 and L_1. The results for these voyages suppose the seconds of its error not to have been affected. The results must, however, be rejected.

Longitudes by voyages of 1855—Continued.

No. of chron.	Voyage.	$\lambda \pm \delta\lambda$	Prob. error.	Weight	k''	t'	ε'	ε''	$\frac{H}{t'}$	$\frac{k}{2}$	$\overset{\delta}{\theta}\ \lambda$	Result. Long.
								s.		s.		
9	L_1	4 32 36.73	± 1.97	9	± 0.18	13.2	± 0.16	± 2.38	— 0.06	— 0.38	+ 0.30	37.03
	C_1	4 32 32.34	2.22	7	"	14.2	.11	2.56	— 0.23	— 0.38	+ 1.24	33.58
	L_2	4 32 32.63	1.70	12	"	11.4	.11	2.05	+ 0.07	— 0.38	— 0.30	32.33
	C_2	4 32 33.17	1.70	12	"	11.2	.11	2.02	+ 0.10	— 0.38	— 0.43	32.74
	L_3	4 32 34.66	2.08	8	"	13.4	.27	2.41	+ 0.05	— 0.38	— 0.20	34.46
	C_3	4 32 31.39	± 1.78	11	"	11.9	.12	2.14	— 0.06	— 0.38	+ 0.27	31.66
10	L_1	4 32 64.66	± 0.00	0	± 1.13	13.2	± 0.16	±14.92	— 0.07	— 0.30	+ 0.28	64.94
	C_1	4 32 28.70	0.00	0	1.13	14.2	.11	16.05	— 0.19	— 0.30	+ 0.81	29.51
	L_2	4 32 36.42	0.00	0	1.13	11.4	.21	12.88	+ 0.11	— 0.30	— 0.38	36.04
	C_2	4 32 40.15	0.00	0	1.13	11.2	.11	12.66	+ 0.09	— 0.30	— 0.30	39.85
	L_3	4 32 34.59	2.22	7	0.20	13.4	.27	2.68	+ 0.11	— 0.30	— 0.44	34.15
	C_3	4 32 27.92	± 2.08	8	0.20	11.9	.88	2.38	— 0.05	— 0.30	+ 0.18	28.10
11	L_1	4 32 76.84	± 0.00	0	± 1.45	13.3	± 0.16	±19.28	— 0.10	— 0.20	+ 0.26	77.10
	C_1	4 32 26.15	0.00	0	1.45	14.2	.11	20.59	+ 0.35	— 0.20	— 0.99	25.16
	L_2	4 32 38.02	0.00	0	1.45	11.4	.21	16.53	— 0.62	— 0.20	+ 1.41	39.43
	C_2	4 32 38.49	0.00	0	1.45	11.3	.11	16.38	— 0.06	— 0.20	+ 0.13	38.62
	L_3	4 32 36.48	2.64	5	0.23	13.4	.27	3.08	+ 0.48	— 0.20	— 1.29	35.19
	C_3	4 32 28.23	± 2.41	6	0.23	11.9	0.88	2.74	+ 0.01	— 0.20	— 0.02	28.21
12	L_1	4 32 59.94	± 0.00	0	± 1.45	13.3	± 0.16	±19.28	— 0.06	— 0.21	+ 0.17	60.11
	C_1	4 32 34.04	0.00	0	1.45	14.2	.11	20.59	— 0.22	— 0.21	+ 0.66	34.70
	L_2	4 32 32.04	0.00	0	1.45	11.4	.21	16.53	+ 0.21	— 0.21	— 0.50	31.54
	C_2	4 32 36.39	0.00	0	1.45	11.3	.11	16.38	+ 0.08	— 0.21	— 0.19	36.20
	L_3	4 32 33.49	1.70	12	0.15	13.4	.27	2.01	+ 0.05	— 0.21	— 0.14	33.35
	C_3	4 32 29.34	± 1.70	12	0.15	11.9	.88	1.78	— 0.06	— 0.21	— 0.15	29.19
13	L_1	4 32 36.86	± 2.94	4	± 0.26	13.3	± 0.16	± 3.46	— 0.08	— 0.19	+ 0.20	37.06
	C_1	4 32 31.65	2.94	4	"	14.2	.11	3.69	+ 0.20	— 0.19	— 0.54	31.11
	L_2	4 32 34.96	2.41	6	"	11.4	.11	2.96	— 0.18	— 0.19	+ 0.39	35.35
	C_2	4 32 24.85	2.41	6	"	11.3	.11	2.94	— 0.01	— 0.19	+ 0.02	24.87
	L_3	4 32 35.84	2.94	4	"	13.4	.27	3.48	+ 0.27	— 0.19	— 0.69	35.15
	C_3	4 32 28.40	± 2.64	5	"	11.9	.12	3.09	+ 0.02	— 0.19	— 0.05	28.35
14	L_1	4 32 28.81	± 1.70	12	± 0.16	13.3	± 0.16	± 2.13	— 0.04	— 0.45	+ 0.24	29.05
	C_1	4 32 33.84	1.97	9	"	14.2	.11	2.27	— 0.34	— 0.45	+ 2.17	26.01
	L_2	4 32 28.59	1.52	15	"	11.4	.13	1.82	+ 0.04	— 0.45	— 0.21	28.38
	C_2	4 32 33.23	1.70	12	"	13.0	.16	2.08	+ 0.18	— 0.45	— 1.05	32.18
	L_3	4 32 28.43	1.78	11	"	13.4	.27	2.14	— 0.04	— 0.45	+ 0.24	28.67
	C_3	4 32 31.85	± 1.58	14	"	11.9	.12	1.90	— 0.08	— 0.45	+ 0.43	32.28
15	L_1	4 32 33.54	± 2.08	8	± 0.19	13.3	± 0.16	± 2.53	+ 0.01	— 0.36	— 0.05	33.49
	C_1	4 32 32.12	2.22	7	"	14.2	.11	2.70	— 0.71	— 0.36	+ 3.63	35.75
	L_2	4 32 31.68	1.87	10	"	11.4	.13	2.17	+ 0.35	— 0.36	— 1.44	30.24
	C_2	4 32 32.46	2.08	8	"	13.0	.16	2.47	+ 0.23	— 0.36	— 1.08	31.38
	L_3	4 32 27.28	2.08	8	"	13.4	.27	2.55	— 0.28	— 0.36	+ 1.35	28.63
	C_3	4 32 36.47	± 1.97	9	"	11.9	.12	2.26	— 0.18	— 0.36	+ 0.77	37.24
16	L_1	4 32 31.22	± 1.70	12	± 0.15	13.3	± 0.16	± 1.99	— 0.05	— 0.45	+ 0.30	31.52
	C_1	4 32 31.00	1.78	11	"	14.2	.11	2.13	— 0.21	— 0.45	+ 1.34	32.34
	L_2	4 32 31.13	1.43	17	"	11.4	.13	1.71	+ 0.06	— 0.45	— 0.31	30.82
	C_2	4 32 31.31	1.64	13	"	13.0	.16	1.95	+ 0.13	— 0.45	— 0.76	30.55
	L_3	4 32 29.31	1.70	12	"	13.4	.27	2.01	+ 0.03	— 0.45	— 0.18	29.13
	C_3	4 32 28.95	± 1.52	15	"	11.9	.12	1.78	— 0.05	— 0.45	+ 0.22	29.17
17	L_1	4 32 34.57	± 2.41	6	± 0.22	13.3	± 0.16	± 2.93	— 0.16	— 0.22	+ 0.47	35.04
	C_1	4 32 30.55	2.64	5	"	14.2	.11	3.12	+ 0.75	— 0.22	— 2.34	28.21
	L_2	4 32 29.05	2.08	8	"	11.4	.13	2.51	— 0.53	— 0.22	+ 1.33	30.38
	C_2	4 32 38.86	2.41	6	"	13.0	.16	2.86	— 0.07	— 0.22	+ 0.20	39.06
	L_3	4 32 35.62	2.41	6	"	13.4	.27	2.95	+ 0.65	— 0.22	— 1.92	33.70
	C_3	4 32 33.10	± 2.22	7	0.22	11.9	0.12	2.62	+ 0.20	— 0.22	— 0.52	32 58
18	L_1	4 32 41.78	± 5.90	1	± 0.45	13.3	± 0.16	± 5.98	— 0.07	— 0.30	+ 0.28	42.06
	C_1	4 32 28.89	5.90	1	"	14.3	.11	6.43	— 0.03	— 0.30	+ 0.13	29.02
	L_2	4 32 41.90	4.17	2	"	11.4	.13	5.13	— 0.05	— 0.30	+ 0.17	42.07
	C_2	4 32 19.34	5.90	1	"	13.0	.16	5.85	+ 0.10	— 0.30	— 0.39	18.95
	L_3	4 32 36.30	5.90	1	"	13.4	.27	6.03	+ 0.14	— 0.30	— 0.56	35.74
	C_3	4 32 26.89	± 4.17	2	"	11.9	.12	5.35	— 0.02	— 0.30	+ 0.07	26.96

Longitudes by voyages of 1855—Continued.

No. of chron.	Voyage.	$\lambda \pm \delta\lambda$	Prob. error.	Weight	k''	t'	ε'	ε''	$\frac{H}{t'}$	$\frac{k}{s}$	$\delta_\theta \lambda$	Result. Long.
								s.		s.		
19	L_1	4 32 33.30	± 3.40	3	± 0.29	13.3	± 0.16	± 3.86	— 0.06	— 0.34	+ 0.27	33.57
	C_1	4 32 39.87	3.40	3	“	14.3	.11	4.15	— 0.52	— 0.34	+ 2.51	42.38
	L_2	4 32 26.08	2.64	5	“	11.4	.13	3.31	+ 0.24	— 0.34	— 0.93	25.15
	C_2	4 32 33.46	2.94	4	“	13.0	.16	3.77	+ 0.21	— 0.34	— 0.93	32.53
	L_3	4 32 32.55	3.40	3	“	13.3	.27	3.86	— 0.17	— 0.34	+ 0.77	33.32
	C_3	4 32 27.91	± 2.94	4	“	11.9	.12	3.45	— 0.14	— 0.34	+ 0.57	28.48
20	L_1	4 32 21.77	± 2.94	4	± 0.27	13.3	± 0.16	± 3.59	— 0.07	— 0.46	+ 0.43	22.20
	C_1	4 32 29.91	3.40	3	“	14.3	.11	3.86	— 0.28	— 0.46	+ 1.83	31.74
	L_2	4 32 33.12	2.64	5	“	11.4	.11	3.08	+ 0.14	— 0.46	— 0.73	32.39
	C_2	4 32 22.97	2.64	5	“	11.2	.11	3.02	+ 0.11	— 0.46	— 0.57	22.40
	L_3	4 32 32.03	2.94	4	“	13.4	.27	3.62	— 0.02	— 0.46	+ 0.12	32.15
	C_3	4 32 29.23	± 2.64	5	“	11.9	.12	3.21	— 0.08	— 0.46	+ 0.44	29.67
21	L_1	4 32 30.53	± 1.97	9	± 0.18	13.3	± 0.16	± 2.39	— 0.09	— 0.32	+ 0.38	30.91
	C_1	4 32 34.13	2.22	7	“	14.3	.11	2.57	+ 0.49	— 0.32	— 3.70	30.43
	L_2	4 32 24.09	1.70	12	“	11.4	.11	2.05	— 0.38	— 0.32	+ 1.39	25.48
	C_2	4 32 27.60	1.70	12	“	11.2	.11	2.02	+ 0.03	— 0.32	— 0.11	27.49
	L_3	4 32 37.16	2.08	8	“	13.4	.27	2.41	+ 0.28	— 0.32	— 0.20	35.96
	C_3	4 32 30.04	± 1.78	11	“	11.9	.12	2.14	+ 0.06	— 0.32	— 0.23	29.81
22	L_1	4 32 31.46	± 1.97	9	± 0.18	13.3	± 0.16	± 2.39	— 0.08	— 0.38	+ 0.40	31.86
	C_1	4 32 36.40	2.22	7	“	14.3	.11	2.57	+ 0.03	— 0.38	— 0.16	36.24
	L_2	4 32 34.64	1.70	12	“	11.4	.11	2.05	— 0.07	— 0.38	+ 0.30	34.94
	C_2	4 32 31.26	1.70	12	“	11.2	.11	2.02	+ 0.08	— 0.38	— 0.34	30.92
	L_3	4 32 28.98	2.08	8	“	13.4	.27	2.41	+ 0.10	— 0.38	— 0.51	28.47
	C_3	4 32 34.24	± 1.78	11	“	11.9	.12	2.14	— 0.02	— 0.38	+ 0.09	34.33
23	L_1	4 32 29.54	± 2.08	8	± 0.19	13.3	± 0.16	± 2.53	— 0.06	— 0.33	+ 0.26	29.80
	C_1	4 32 27.52	2.22	7	“	14.3	.11	2.72	— 0.54	— 0.33	+ 4.31	31.83
	L_2	4 32 21.30	1.87	10	“	11.4	.11	2.17	+ 0.31	— 0.33	— 1.17	20.13
	C_2	4 32 35.46	1.78	11	“	11.2	.11	2.13	+ 0.13	— 0.33	— 0.48	34.98
	L_3	4 32 30.20	2.08	8	“	13.4	.27	2.55	— 0.13	— 0.33	+ 0.57	30.77
	C_3	4 32 30.73	± 1.87	10	0.19	11.9	0.12	2.26	— 0.12	— 0.33	+ 0.47	31.20
24	L_1	4 32 32.03	± 1.97	9	± 0.18	13.3	± 0.16	± 2.39	— 0.06	— 0.25	+ 0.20	32.23
	C_1	4 32 34.93	2.08	8	“	14.3	.11	2.57	— 0.41	— 0.25	+ 1.46	36.39
	L_2	4 32 33.98	1.70	12	“	11.4	.11	2.05	+ 0.22	— 0.25	— 0.63	33.35
	C_2	4 32 33.50	1.70	12	“	11.2	.11	2.02	+ 0.12	— 0.25	— 0.34	33.16
	L_3	4 32 33.89	2.08	8	“	13.4	.27	2.41	— 0.08	— 0.25	+ 0.27	34.16
	C_3	4 32 32.30	± 1.78	11	“	11.9	.12	2.14	— 0.09	— 0.25	+ 0.27	32.57
25	L_1	4 32 29.99	± 1.70	12	± 0.15	13.3	± 0.16	± 1.99	— 0.12	— 0.24	+ 0.38	30.37
	C_1	4 32 37.70	1.78	11	“	14.3	.11	2.14	+ 1.23	— 0.24	— 4.19	33.51
	L_2	4 32 26.70	1.43	17	“	11.4	.11	1.71	— 0.88	— 0.24	+ 2.41	29.11
	C_2	4 32 31.95	1.43	17	“	11.2	.11	1.68	+ 0.01	— 0.24	— 0.03	31.92
	L_3	4 32 31.25	1.70	12	“	13.4	.27	2.01	+ 0.58	— 0.24	— 1.87	29.38
	C_3	4 32 32.20	± 1.52	15	“	12.0	.12	1.80	+ 0.19	— 0.24	— 0.55	31.65
26	L_1	4 32 27.30	± 3.40	3	± 0.31	13.3	± 0.16	± 4.12	— 0.22	— 0.050	+ 0.15	27.45
	C_1	4 32 35.24	3.40	3	“	14.3	.13	4.43	+ 5.56	— 0.050	— 3.95	31.29
	L_2	4 32 30.00	2.94	4	“	11.5	.11	3.56	— 1.88	— 0.050	+ 1.07	31.07
	C_2	4 32 35.23	2.94	4	“	11.3	.11	3.50	— 0.61	— 0.050	+ 0.34	35.57
	L_3	4 32 33.87	3.40	3	“	13.4	.27	4.15	+ 2.76	— 0.050	— 1.85	32.02
°	C_3	4 31 12.66	± 0.00	0	“	11.9	.12	3.69	+ 0.81	— 0.050	— 0.48	12.18
27	L_1	4 32 30.76	± 1.70	12	± 0.15	13.3	± 0.16	± 1.99	— 0.05	— 0.16	+ 0.11	30.87
	C_1	4 32 32.88	1.78	11	“	14.3	.11	2.14	+ 0.49	— 0.16	— 1.11	31.77
	L_2	4 32 30.12	1.43	17	“	11.4	.11	1.71	— 0.52	— 0.16	+ 0.95	31.07
	C_2	4 32 31.34	1.43	17	“	11.3	.11	1.69	— 0.18	— 0.16	+ 0.32	31.66
	L_3	4 32 33.86	1.70	12	“	13.4	.27	2.01	+ 1.03	— 0.16	— 2.21	31.65
	C_3	4 32 32.02	± 1.52	15	“	11.9	.12	1.78	— 0.06	— 0.16	+ 0.11	32.13
28	L_1	4 32 30.66	± 2.94	4	± 0.25	13.3	± 0.16	± 3.32	+ 0.02	— 0.106	— 0.03	30.63
	C_1	4 32 39.84	2.94	4	“	14.3	.11	3.57	+ 1.68	— 0.106	— 2.53	37.31
	L_2	4 32 31.88	2.41	6	“	11.5	.11	2.87	— 1.48	— 0.106	+ 1.79	33.67
	C_2	4 32 34.23	2.41	6	“	11.3	.11	2.82	— 0.72	— 0.106	+ 0.85	35.08
	L_3	4 32 34.77	2.94	4	“	13.4	.27	3.35	+ 2.73	— 0.106	— 3.88	30.89
	C_3	4 32 34.72	± 2.64	5	“	11.9	.12	2.97	— 0.06	— 0.106	+ 0.76	35.48

° On September 25 No. 26 received a blow which altered its error by 1*m.* 20*s*; the longitude by the voyage C_3 has been on account rejected.

Longitudes by voyages of 1855—Continued.

No. of chron.	Voyage.	$\lambda \pm \delta\lambda$	Prob. error.	Weight	k''	t'	ε'	ε''	$\frac{H}{t'}$	$\frac{k}{s}$	$\delta_\theta \lambda$	Result. Long.
								s.		s.		
29	L_1	4 32 38.96	± 2.94	4	± 0.27	13.3	± 0.16	± 3.59	− 0.11	+ 0.11	− 0.16	38.80
	C_1	4 32 36.16	3.40	3	"	14.3	.11	3.86	− 0.99	+ 0.11	− 1.55	34.61
	L_2	4 32 37.33	2.64	5	"	11.4	.11	3.08	− 0.08	+ 0.11	− 0.10	37.23
	C_2	4 32 30.82	2.64	5	"	11.3	.11	3.05	+ 0.32	+ 0.11	+ 0.39	31.21
	L_3	4 32 33.19	2.94	4	"	13.4	.27	3.62	− 0.53	+ 0.11	− 0.78	32.41
	C_3	4 32 31.85	± 2.64	5	"	11.9	0.12	3.21	− 0.06	+ 0.11	− 0.08	31.77
30	L_1	4 32 33.77	± 2.94	4	± 0.27	13.3	± 0.16	± 3.59	− 0.08	− 0.19	+ 0.20	33.97
	C_1	4 32 45.02	3.40	3	"	14.2	.11	3.83	+ 1.61	− 0.19	− 4.34	40.68
	L_2	4 32 30.72	2.64	5	"	11.4	.11	3.08	− 0.20	− 0.19	+ 0.04	30.76
	C_2	4 32 25.84	2.64	5	"	11.3	.11	3.05	− 0.18	− 0.19	+ 0.38	26.22
	L_3	4 32 31.49	2.94	4	"	13.4	.27	3.62	+ 0.83	− 0.19	− 2.11	29.38
	C_3	4 32 26.53	± 2.64	5	"	12.0	.12	3.24	+ 0.35	− 0.19	− 0.80	25.73
31	L_1	4 32 36.31	± 4.17	2	± 0.40	13.3	± 0.16	± 5.32	+ 0.68	+ 0.047	+ 0.43	36.74
	C_1	4 32 33.52	4.17	2	"	14.2	.11	5.68	− 3.72	+ 0.047	− 2.47	31.05
	L_2	4 32 34.97	4.17	2	"	11.3	.11	4.52	+ 1.50	+ 0.047	+ 0.80	35.77
	C_2	4 32 22.83	3.40	3	"	11.2	.11	4.48	+ 0.90	+ 0.047	+ 0.48	23.31
	L_3	4 32 38.72	4.17	2	"	13.4	.27	5.36	− 2.13	+ 0.047	− 1.34	37.38
	C_3	4 32 19.14	± 4.17	2	"	11.9	.12	4.76	− 0.16	+ 0.047	− 0.09	19.05
32	L_1	4 32 33.76	± 1.70	12	± 0.15	13.3	±0.16	± 1.99	− 0.08	− 0.27	+ 0.29	34.05
	C_1	4 32 37.94	1.78	11	"	14.2	.11	2.13	+ 1.77	− 0.27	− 6.79	31.15
	L_2	4 32 31.30	1.43	17	"	11.4	.11	1.71	− 0.70	− 0.27	+ 2.15	33.45
	C_2	4 32 29.58	1.43	17	"	11.3	.11	1.69	− 0.26	− 0.27	+ 0.79	30.37
	L_3	4 32 36.46	1.70	12	"	13.4	.27	2.01	+ 1.05	− 0.27	− 3.80	32.66
	C_3	4 32 33.00	± 1.52	15	"	11.9	.12	1.78	− 0.01	− 0.27	+ 0.03	33.03
33	L_1	4 32 47.08	± 4.17	2	± 0.39	13.3	± 0.16	± 5.19	− 0.08	− 0.25	+ 0.26	47.34
	C_1	4 32 26.03	4.17	2	"	14.2	.11	5.54	− 0.01	− 0.25	+ 0.04	26.07
	L_2	4 32 41.38	3.40	3	"	11.4	.11	4.45	− 0.05	− 0.25	+ 0.14	41.52
	C_2	4 32 31.60	3.40	3	"	11.3	.11	4.41	+ 0.10	− 0.25	− 0.28	31.32
	L_3	4 32 31.11	4.17	2	"	13.4	.27	5.23	+ 0.12	− 0.25	− 0.40	30.71
	C_3	4 32 29.67	± 4.17	2	"	11.9	.12	4.64	− 0.06	− 0.25	+ 0.18	29.85
34	L_1	4 32 23.17	± 4.17	2	± 0.37	13.3	± 0.16	± 4.92	− 0.09	− 0.62	+ 0.74	23.91
	C_1	4 32 28.84	4.17	2	"	14.2	.11	5.25	− 0.45	− 0.62	+ 3.96	32.80
	L_2	4 32 27.55	3.40	3	"	11.4	.11	4.22	+ 0.19	− 0.62	− 1.34	26.21
	C_2	4 32 42.12	3.40	3	"	11.3	.11	4.18	+ 0.16	− 0.62	− 1.11	41.01
	L_3	4 32 35.27	4.17	2	"	13.4	.27	4.96	− 0.10	− 0.62	+ 0.83	36.10
	C_3	4 32 25.90	± 3.40	3	"	11.9	.12	4.40	− 0.09	− 0.62	+ 0.66	26.56
35	L_1	4 32 31.11	± 1.70	12	± 0.15	13.3	± 0.16	± 1.99	0.00	0	0.00	31.11
	C_1	4 32 35.57	1.78	11	"	14.2	.11	2.13	− 0.31	0	− 6.56	29.01
	L_2	4 32 31.60	1.43	17	"	11.4	.11	1.71	+ 0.20	0	+ 3.40	35.00
	C_2	4 32 30.49	1.43	17	"	11.3	.11	1.69	+ 0.06	0	+ 1.00	31.49
	L_3	4 32 30.61	1.70	12	"	13.4	.27	2.01	− 0.16	0	− 3.19	27.42
	C_3	4 32 32.59	± 1.52	15	0.15	11.9	0.12	1.78	− 0.05	0	− 0.89	31.70
36	L_1	4 32 22.76	± 2.94	4	± 0.25	13.3	± 0.16	± 3.32	− 0.09	− 0.48	+ 0.57	23.33
	C_1	4 32 35.00	2.94	4	"	14.2	.11	3.55	− 0.26	− 0.48	+ 1.77	36.77
	L_2	4 32 25.48	2.41	6	"	11.4	.11	2.85	+ 0.06	− 0.48	− 0.33	25.15
	C_2	4 32 30.61	2.41	6	"	11.3	.11	2.82	+ 0.12	− 0.48	− 0.65	29.96
	L_3	4 32 31.42	2.64	5	"	13.4	.27	3.35	0.00	− 0.48	− 0.00	31.42
	C_3	4 32 28.87	± 2.41	6	"	11.9	.12	2.97	− 0.06	− 0.48	+ 0.34	29.21
37	L_1	4 32 26.10	± 1.97	9	± 0.17	13.3	± 0.66	± 2.26	+ 0.14	− 0.102	− 0.19	25.91
	C_1						.11					
	L_2	4 32 30.06	1.64	13	0.17	11.4	.11	1.94	− 1.60	− 0.102	+ 0.70	30.76
	C_2	4 32 34.39	1.58	14	"	11.3	.11	1.92	− 0.25	− 0.102	+ 0.29	34.68
	L_3	4 32 34.02	1.87	10	"	13.4	.27	2.28	+ 1.40	− 0.102	− 1.91	32.11
	C_3	4 32 33.92	± 1.70	12	"	11.9	.12	2.00	+ 0.29	− 0.102	− 0.35	33.57
38	L_1	4 32 31.82	± 1.78	11	± 0.15	13.3	± 0.66	± 1.99	− 0.12	− 0.32	+ 0.51	32.33
	C_1						.11					
	L_2	4 32 28.79	1.43	17	0.15	11.4	.11	1.71	+ 0.02	− 0.32	− 0.07	28.72
	C_2	4 32 35.32	1.43	17	"	11.3	.11	1.69	+ 0.10	− 0.32	− 0.36	34.96
	L_3	4 32 31.53	1.70	12	"	13.4	.27	2.01	+ 0.02	− 0.32	− 0.09	31.44
	C_3	4 32 33.19	± 1.52	15	"	11.9	.12	1.78	− 0.06	− 0.32	+ 0.23	33.42

Longitudes by voyages of 1855—Continued.

No. of chron.	Voyage.	$\lambda \pm \delta\lambda$	Prob. error.	Weight	k''	t'	ε'	ε''	$\frac{H}{t'}$	$\frac{k}{2}$	$\delta_\theta \lambda$	Result. Long.
								s.		s.		
39	L_1	4 32 32.51	± 1.87	10	± 0.16	13.3	± 0.66	± 2.13	+ 0.07	— 0.162	— 0.15	32.36
	C_1						.11					
	L_2	4 32 33.24	1.52	15	0.16	11.4	.11	1.82	— 0.59	— 0.162	+ 1.09	34.33
	C_2	4 32 29.76	1.52	15	"	11.2	.11	1.79	— 0.38	— 0.162	+ 0.69	30.45
	L_3	4 32 37.40	1.78	11	"	13.4	.27	2.14	+ 1.19	— 0.162	— 2.58	34.82
	C_3	4 32 28.40	± 1.58	14	"	11.9	.12	1.90	+ 0.26	— 0.162	— 0.50	27.90
40	L_1				± 0.21		± 0.16					
	C_1						.11					
	L_2	4 32 33.96	± 1.97	9	0.20	11.4	.30	± 2.28	+ 0.02	— 0.27	— 0.06	33.90
	C_2						.11					
	L_3	4 32 34.70	2.22	7	0.20	13.4	.40	2.68	+ 0.64	— 0.27	— 2.32	32.38
	C_3	4 32 30.27	± 1.97	9	"	11.9	.12	2.38	+ 0.09	— 0.27	— 0.29	29.98
41	L_1						± 0.16					
	C_1						.11					
	L_2	4 32 35.91	± 1.97	9	± 0.20	11.4	.30	± 2.28	+ 0.01	— 0.27	— 0.03	35.88
	C_2						.11					
	L_3	4 32 34.29	2.22	7	0.20	13.4	.40	2.68	+ 0.59	— 0.27	— 2.13	32.16
	C_3	4 32 31.36	± 1.97	9	0.20	12.0	0.12	2.40	+ 0.08	— 0.27	— 0.26	31.10
42	L_1						± 0.16					
	C_1						.11					
	L_2	4 32 38.06	± 1.97	9	± 0.20	11.4	.30	± 2.28	— 0.03	— 0.27	+ 0.09	38.15
	C_2						.11					
	L_3	4 32 32.30	2.22	7	0.20	13.4	.40	2.68	+ 0.32	— 0.27	— 1.16	31.14
	C_3	4 32 31.31	± 1.97	9	0.20	11.9	.12	2.38	+ 0.01	— 0.27	— 0.03	31.28
43	L_1						± 0.16					
	C_1						.11					
	L_2	4 32 32.48	± 1.97	9	± 0.20	11.4	.30	± 2.28	— 0.05	— 0.27	+ 0.15	32.63
	C_2						.11					
	L_3	4 32 33.53	2.22	7	0.20	13.4	.40	2.68	+ 0.12	— 0.27	— 0.43	33.10
	C_3	4 32 33.32	± 1.97	9	"	11.9	.12	2.38	— 0.04	— 0.27	+ 0.13	33.45
44	L_1						± 0.16					
	C_1						.11					
	L_2	4 32 24.57	± 2.64	5	± 0.27	11.4	.30	± 3.08	— 0.05	— 0.27	+ 0.15	24.72
	C_2						.11					
	L_3	4 32 33.92	2.94	4	0.27	13.4	.40	3.62	+ 0.72	— 0.27	— 2.60	31.32
	C_3	4 32 36.83	± 2.64	5	"	11.9	.12	3.21	+ 0.06	— 0.27	— 0.19	36.64
45	L_1						± 0.16					
	C_1						.11					
	L_2	4 32 32.24	± 1.97	9	± 0.20	11.4	.30	± 2.28	— 0.05	— 0.16	+ 0.09	32 33
	C_2						.11					
	L_3	4 32 31.97	2.22	7	0.20	13.4	.27	2.68	+ 0.23	— 0.16	— 0.49	31.48
	C_3	4 32 32.18	± 1.97	9	"	11.9	.12	2.38	+ 0.02	— 0.16	— 0.04	32.14
A.	L_1	4 32 38.19	± 3.40	3	± 0.34	13.3	± 0.16	± 4.52	+ 0.17	— 0.12	— 0.20	37.99
	C_1	4 32 25.03	4.17	2	"	14.2	.11	4.83	+ 2.28	— 0.12	— 3.90	21.13
	L_2	4 32 33.38	3.40	3	"	11.4	.11	3.88	— 0.9	— 0.12	+ 1.19	34.57
	C_2	4 32 35.95	3.40	3	"	11.2	.11	3.81	— 0.93	— 0.12	+ 1.12	37.07
	L_3	4 32 34.81	4.17	2	"	13.4	.27	4.56	+ 1.72	— 0.12	— 2.30	32.51
	C_3	4 32 29.68	± 3.40	3	"	12.0	.12	4.08	+ 0.59	— 0.12	— 0.86	28.82
D.	L_1	4 32 26.16	± 2.64	5	± 0.24	13.3	± 0.16	± 3.19	— 0.05	— 0.22	+ 0.15	26.31
	C_1	4 32 35.12	2.94	4	"	14.2	.11	3.41	+ 0.36	— 0.22	— 1.12	34.00
	L_2	4 32 32.58	2.22	7	"	11.4	.11	2.74	— 0.26	— 0.22	+ 0.65	33.23
	C_2	4 32 24.29	2.22	7	"	11.2	.11	2.69	— 0.10	— 0.22	+ 0.25	24.54
	L_3	4 32 36.31	2.64	5	"	13.4	.27	3.22	+ 0.48	— 0.22	— 1.42	34.89
	C_3	4 32 30.26	± 2.41	6	0.24	12.0	.12	2.88	+ 0.12	— 0.22	— 0.32	29.94
U.	L_1	4 32 33.35	± 2.94	4	± 0.25	13.4	± 0.16	± 3 35	+ 0.02	o	+ 0.54	33.89
	C_1	4 32 41.00	2.94	4	"	14.3	.11	3.57	— 0.31	o	— 8.82	32.18
	L_2	4 32 36.93	2.41	6	"	11.5	.11	2.87	+ 0.13	o	+ 2.98	39.91
	C_2	4 32 33.46	2.41	6	"	11.3	.11	2.82	+ 0.07	o	+ 0.79	34.25
	L_3	4 32 29.70	2.94	4	"	13.5	.27	3.37	— 0.08	o	— 1.60	28.10
	C_3	4 32 35.47	± 2.64	5	"	12.1	.12	3.02	— 0.06	o	— 1.44	34.08

Longitude by voyages of 1855—Continued.

No. of chron.	Voyage.	$\lambda \pm \delta\lambda$	Prob. error.	Weight	k''	t'	ε'	ε''	$\frac{H}{t'}$	$\frac{k}{2}$	$\delta_\theta \lambda$	Result. Long.
								s.		s.		
X.	L_1	4 32 38.52	± 2.94	4	± 0.25	13.4	± 0.16	± 3.35	+ 0.01	— 0.19	— 0.03	38.49
	C_1						.11					
	L_2	4 32 36.03	2.41	6	"	11.5	.11	2.87	— 0.69	— 0.19	+ 1.51	37.54
	C_2	4 32 29.88	2.41	6	"	11.3	.11	2.82	— 0.23	— 0.19	+ 0.49	30.37
	L_3	4 32 28.54	2.64	5	"	13.5	.27	3.37	+ 0.43	— 0.19	— 1.11	27.43
	C_3	4 32 31.36	± 2.64	5	"	12.1	.12	3.02	+ 0.28	— 0.19	— 0.64	30.72
Y.	L_1						± 0.16					
	C_1						.11					
	L_2	4 32 33.90	± 3.40	3	± 0.38	11.5	.11	± 4.37	— 0.62	— 0.18	+ 1.28	35.18
	C_2						.11		— 0.25	— 0.18		
	L_3	4 32 32.65	4.17	2	0.38	13.5	.27	5.13	+ 0.60	— 0.18	— 0.15	32.50
	C_3	4 32 43.03	± 4.17	2	0.38	12.1	0.12	4.60	+ 0.25	— 0.18	— 0.54	42.49

° For No. 3, $k_1 = -0.43s.$; No. 4 $k_1 = +0.62s.$; No. 35 $k_1 = +1.49$ A; U $k_1 = +1.99 =$

APPENDIX No. 24.

Report on the method of determining longitudes by occultations of the Pleiades.

BY PROFESSOR BENJAMIN PEIRCE, LL.D., OF HARVARD.

1. The determination of longitudes by occultations of the stars appears to be the most accurate of all astronomical methods for such determinations, and deserves, therefore, a very careful examination in order to ascertain the greatest degree of accuracy of which it is susceptible, and the surest method of securing such accuracy. The sources of error are partly those of observation, and partly of theory. The errors arising from observation are of two classes: first, there are those which are special to the observations of the occultations; and secondly, there are those which are general, and which, from their nature, cannot be discriminated from the theoretical defects.

2. The probable error of the direct observation of an occultation has been investigated by Commander C. H. Davis, from simultaneous observations made by different observers at the same place. From his researches it appears that this probable error is about a fifth of a second of time, so that the ultimate probable error of the mean of this class of observations cannot exceed a twentieth of a second of time. If, therefore, the theoretical defects can be eliminated by proper precautions and a sufficient accumulation of observations, longitudes may be obtained by this method, of which the probable error shall be decidedly inferior to a tenth of a second of time.

3. It is obvious that, with the present uncertainty of the lunar theory, isolated occultations cannot approach this degree of accuracy in the determination of longitudes; but well determined groups of stars are essential to correct the lunar elements, and rectify the places of the stars themselves. The present plan is to carry out the investigations of Walker, published in the Report of 1851, by combining all the known observations of occultations of the Pleiades, and using them for correcting the lunar semi-diameter, the mutual positions and changes of position of the stars of this group, for testing and correcting the formulæ of lunar parallax, for determining the irregularities of the moon's limb, and finally, for correcting the longitudes of the places of observation.

4. Of the various forms of computation which might be adopted, I have selected that which is derived from the stereographic projection of the sphere, in which the star ALCYONE is *the pole*

of projection. The advantage of the stereographic projection consists in the circularity of the projections of all the spherical circles, so that the moon is represented by a circle on the plane of projection. The advantage of placing the pole of projection at the star ALCYONE is, that the distances and relative positions of the projected places of the stars are only affected by the differences of their proper motions and the small differential effects of aberration. There may be a doubt whether the somewhat greater simplicity of the formulæ in the case in which the pole of projection coincides with that of the celestial equator, should not cause this form of projection to be preferred; and it may be advisable, in order to secure accuracy, to conduct the computations independently by each method.

5. As the basis of computation, the places of the stars have been taken from BESSEL's investigations, which are contained in the fourth volume of his "ASTRONOMISCHE UNTERSUCHUNGEN," in the article entitled "*Beobachtungen verschiedener Sterne der Plejaden.*" The places of the moon are taken from the Nautical Almanac, and the moon's parallax and semi-diameter from the "*Tables of the Mo n's Parallax constructed from Walker's and Adams' Formulæ*" for the use of the "*American Ephemeris and Nautical Almanac.*"

6. The following are the formulæ for the computation of the stereographic projections: Let
$\alpha =$ the right ascension of Alcyone.
$\beta =$ the declination of Alcyone.
$\alpha' =$ the right ascension of another star or of the moon's centre.
$\beta' =$ the declination of the second star or of the moon's centre.
$\Delta\,\alpha = \alpha' - \alpha.$
$\Delta\,\beta = \beta' - \beta.$

The axes of x and y have their origin at Alcyone; the axis of y is directed to the north, and that of x to the east. The co-ordinates of the star are given by the formulæ,

$$\mathrm{A} = 1 - \sin^2 \tfrac{1}{2}\,\Delta\,\beta - \sin^2 \tfrac{1}{2}\,\Delta\,\alpha \cos\beta \cos\beta',$$
$$\mathrm{B} \sin 1'' = \sin \Delta\,\alpha \cos\beta',$$
$$\mathrm{C} \sin 1'' = \sin \Delta\,\beta + 2 \sin^2 \tfrac{1}{2}\,\Delta\,\alpha \sin\beta \cos\beta',$$
$$x = \frac{\mathrm{B}}{\mathrm{A}},$$
$$y = \frac{\mathrm{C}}{\mathrm{A}}.$$

The radius of the circle, which represents the moon, is given by the formula,

$$\Sigma_2 = [1 + \tfrac{1}{4}(x^2 + y^2) \sin^2 1''] \,\Sigma_1$$

in which Σ_1 is the augmented semi-diameter of the moon.

The computation of A, C, and Σ_2 should be performed with the aid of the Gaussian logarithms.

7. The formulæ for the correction of latitude for the earth's ellipticity are those used in the Coast Survey derived from BESSEL, and are—

$$\varphi = \text{the geographical latitude of the place,}$$
$$\log e = 8.9122052,$$
$$\log (1 - e^2) = 9.9970916,$$
$$\sin \psi = e \sin \varphi,$$
$$h = \sec \psi \cos \varphi,$$
$$k = (1 - e^2) \sec \psi \sin \varphi.$$

8. The parallax of the moon in right ascension and declination, and its augmented semi-diameter, are obtained by the formulæ of OLBERS, which are

$\pi =$ the moon's equatorial horizontal parallax,
$s =$ the sidereal time at the place of observation,
$\alpha_0 =$ the moon's tabular right ascension,
$\beta_0 =$ the moon's tabular declination,
$\Delta_\pi \alpha = \alpha' - \alpha_0 =$ the parallax in right ascension,
$\Delta_\pi \beta = \beta' - \beta_0 =$ the parallax in declination.

$$P \sin 1'' = h \sin \pi \sec \beta_o,$$
$$\tan \Delta_\pi a = -\frac{P \sin 1'' \sin (s - a_o)}{1 - P \sin 1'' \cos (s - a_o)},$$
$$\tan \eta = \frac{k \cos \frac{1}{2} \Delta_\pi a}{h \cos (s - a_o - \frac{1}{2} \Delta_\pi a)}$$
$$Q \sin 1'' = \frac{k \sin \pi}{\sin \eta}$$
$$\tan \Delta_\pi \beta = \frac{Q \sin 1'' \sin (\beta_o - \eta)}{1 - Q \sin 1'' \cos (\beta_o - \eta)}$$
$$\log a = 9.435000.$$
$$\Sigma_1 = a\,\pi \frac{\sin (\beta' - \eta)}{\sin (\beta_o - \eta)}$$

9. In order to determine the equations of condition for correcting the lunar elements of the places of the stars, and of the longitude of the place, let

- x_m, y_m denote the co-ordinates of the moon's place affected with parallax,
- x_s, y_s those of the star's place,
- p the distance of the star from the centre of the moon for the recorded instant of the observed immersion or emersion,
- θ the angle which p makes with the axis of x,
- θ' the angle which the moon's apparent path, affected by parallax, makes with the axis of x,
- v the velocity of the moon for a second of time, estimated in seconds of space,
- x'_m, y'_m the change in the values of x_m and y_m for a second of time,
- δx_m the correction of the moon's co-ordinate in right ascension for the instant denoted by τ,
- $\delta \beta_m$ the correction of the moon's declination for the instant τ,
- δx_s the correction of the star's co-ordinate in right ascension for the year 1840,
- $\delta \beta_s$ the correction of the star's declination for the year 1840,
- $\delta x'_m$ the correction of the moon's hourly change of x_m,
- $\delta \beta'_m$ the correction of the moon's hourly motion in declination,
- $\delta x'_s$ the correction of the star's annual change of x_s,
- $\delta \beta'_s$ the correction of the star's annual motion in declination,
- $\delta \pi$ the correction of the moon's horizontal parallax,
- δa the correction of the constant ratio (a) of the moon's semi-diameter to its horizontal parallax,
- δb the correction of the moon's semi-diameter for irregularity of outline,
- $\delta \lambda$ the correction of the western longitude of the place in seconds of time,
- δt the correction of seconds of the local time of observation for the night's work,
- t the time expressed in hours and decimals of an hour,
- t_y the time in years from 1840.

The subsidiary formulæ for the determination of p, v, θ and θ' are

$$p \cos \theta = x_s - x_m,$$
$$p \sin \theta = y_s - y_m,$$
$$v \cos \theta' = x'_m,$$
$$v \sin \theta' = y'_m,$$

and the equation of condition is

$$\cos \theta \left[\delta x_s - \delta x_m + t_y\,\delta x'_s - (t - \tau)\,\delta x'_m\right] + \sin \theta \left[\delta \beta_s - \delta \beta_m + t_y\,\delta \beta'_s - (t - \tau)\,\delta \beta'_m\right]$$
$$- \left[\frac{\Delta_\pi a \cos \beta_o}{\pi} \cos \theta + \frac{\Delta_\pi \beta}{\pi} \sin \theta + a\right] \delta \pi - \pi\,\delta a - \delta b - v \cos (\theta' - \theta) \left[\delta \lambda + \delta t\right] = \Sigma_2 - p.$$

10. In computing x_m and y_m by the formulæ of § 6, the apparent right ascension and declination of Alcyone must be taken for the time from the Nautical Almanac.

The values of x_s and y_s must be corrected for proper motion, and also for change in the direction of the axis of x, arising from precession and aberration. The formulæ for the computation of these changes are given in the following paper, with their investigations by Dr. Peters.

Formulæ for the correction of the co-ordinates of the stars.

Let the accented letters refer to the apparent position, the unaccented letters to the mean place of 1840.0, and the index s to the star, and we have

$$A\, x_s = \sin(\alpha_s - \alpha) \cos \beta_s$$
$$A\, x'_s = \sin(\alpha'_s - \alpha') \cos \beta'_s$$
$$A\, y_s = \sin(\beta_s - \beta) + 2 \sin^2 \tfrac{1}{2} (\alpha_s - \alpha) \sin \beta \cos \beta_s$$
$$A\, y'_s = \sin(\beta'_s - \beta') + 2 \sin^2 \tfrac{1}{2} (\alpha'_s - \alpha') \sin \beta' \cos \beta'_s$$

Hence, by neglecting the terms of the higher orders, the corrections of the co-ordinates are

$$x'_s - x_s = (\alpha'_s - \alpha_s - \alpha' + \alpha) \cos \beta - (\alpha_s - \alpha)(\beta' - \beta) \sin \beta$$
$$y'_s - y_s = \beta'_s - \beta_s - \beta' + \beta.$$

If, then, Bessel's notation is adopted for A, B, C, and D, and if only the principal terms are retained, so that

$$A = t_y - 0.34238 \sin \Omega$$
$$B = -9''.2235 \cos \Omega$$
$$C = -20''.4451 \cos \omega \cos \odot$$
$$D = -20''.4451 \sin \odot$$
$$\Omega = 339^\circ\ 35'\ 44''.7 - t_y\ (19^\circ\ 20'\ 29''.53)$$
$$= 339^\circ\ 35'\ 44''.7 - (t_y \pm 18^y.61\, i)\ 19^\circ\ 20'\ 29''.53,$$

in which i is any integer; the formulæ are—

For *Alcyone* $\alpha' - \alpha = A\, a + B\, b + C\, c + D\, d,$

$$\beta' - \beta = A\, a_1 + B\, b_1 + C\, c_1 + D\, d_1.$$

For the other stars the formulæ are the same with the index s annexed. The substitution of these equations gives

$$x'_s - x_s = A\,(a_s - a) \cos \beta + B\,(b_s - b) \cos \beta + C\,(c_s - c) \cos \beta + D(d_s - d) \cos \beta$$
$$- (\alpha_s - \alpha) \sin \beta\,(A\, a_1 + B\, b_1 + C\, c_1 + D\, d_1)$$
$$y'_s - y_s = A\,(a_s - a)_1 + B\,(b_s - b)_1 + C\,(c_s - c)_1 + D\,(d_s - d)_1$$

But the values of a, b, c, &c., are

$a = m + n \tan \beta \sin \alpha$, whence $a_s - a = n \tan \beta \cos \alpha\,(\alpha_s - \alpha) + n \sec^2 \beta \sin \alpha\,(\beta_s - \beta)$,
$b = \tan \beta \cos \alpha$, $\quad b_s - b = -\tan \beta \sin \alpha\,(\alpha_s - \alpha) + \sec^2 \beta \cos \alpha\,(\beta_s - \beta)$,
$c = \sec \beta \cos \alpha$, $\quad c_s - c = -\sec \beta \sin \alpha\,(\alpha_s - \alpha) + \sec^2 \beta \sin \beta \cos \alpha\,(\beta_s - \beta)$,
$d = \sec \beta \sin \alpha$, $\quad d_s - d = \sec \beta \cos \alpha\,(\alpha_s - \alpha) + \sec^2 \beta \sin \beta \sin \alpha\,(\beta_s - \beta)$,
$a_1 = n \cos \alpha$, $\quad (a_s - a)_1 = -n \sin \alpha\,(\alpha_s - \alpha)$,
$b_1 = -\sin \alpha$, $\quad (b_s - b)_1 = -\cos \alpha\,(\alpha_s - \alpha)$,
$c_1 = \tan \omega \cos \beta - \sin \beta \sin \alpha$, $(c_s - c)_1 = -\sin \beta \cos \alpha\,(\alpha_s - \alpha) - (\tan \omega \sin \beta + \cos \beta \sin \alpha)(\beta_s - \beta)$,
$d_1 = \sin \beta \cos \alpha$, $\quad (d_s - d)_1 = -\sin \beta \sin \alpha\,(\alpha_s - \alpha) + \cos \beta \cos \alpha\,(\beta_s - \beta)$.

The substitution of these values gives

$$x'_s - x_s = (An \sec \beta \sin \alpha + B \sec \beta \cos \alpha + C \tan \beta \cos \alpha + D \tan \beta \sin \alpha) y_s$$
$$- (C \tan \omega \sin \beta + C \cos \beta \sin \alpha - D \cos \beta \cos \alpha)\, x_s,$$
$$y'_s - y_s = -(An \sec \beta \sec \alpha + B \sec \beta \cos \alpha + C \tan \beta \cos \alpha + D \tan \beta \sin \alpha)\, x_s$$
$$- (C \tan \omega \sin \beta + C \cos \beta \sin \alpha - D \cos \beta \cos \alpha)\, y_s.$$

In these formulæ the following are the numerical values of the various quantities:

	log. tan ω	log. cos ω	log. n	log. sin α	log. cos α	log. sin β	log. cos β	log. tan β
For 1840;	9.63747	9.96253	1.30224	9.91246	9.76043	9.60252	9.96205	9.64047
1740;	9.63769	9.96250	1.30245	9.90437	9.77587	9.59679	9.96313	9.63367

If then (the numerical coefficients being replaced by their logarithms) the notation is adopted:

For 1840: $E = 5.9382\, t_y - 5.6118 \sin [336^\circ\, 59' + (t_y \pm 18^y.61)\, 19^\circ\, 20'.5] + 5.6248 \sin (212^\circ\, 53' + \odot)$

1740: $E = 5.9293\, t_y - 5.6140 \sin [336^\circ\, 30' + (t_y \pm 18^y.61)\, 19^\circ\, 20'.5] + 5.6172 \sin (214^\circ\, 18' + \odot)$

For 1840: $F = 5.9951 \sin (121^\circ\, 56' + \odot)$

1740: $F = 5.9952 \sin (122^\circ\, 20' + \odot)$

the values of the corrections of the co-ordinates become

$$x_s' - x_s = E\, y_s + F\, x_s$$
$$y_s' - y_s = -E\, x_s + F\, y_s$$

The maximum of the co-ordinates does not amount to 2800″, so that the maxima of the corrections are easily derived from the following forms:

For 1840: $2800''\, E = 0''.2428\, t_y + 0''.115 \sin [336^\circ\, 59' + (t_y \pm i\, 18^y.61)\, 19^\circ\, 20'.5] + 0''.118 \sin (212^\circ\, 53' + \odot)$

1740: $2800''\, E = 0''.2379\, t_y + 0''.115 \sin [336^\circ\, 30' + (t_y \pm i\, 18^y.61)\, 19^\circ\, 20'.5] + 0''.116 \sin (214^\circ\, 18' + \odot)$

For 1840: $2800''\, F = 0''.277 \sin (121^\circ\, 56' + \odot)$

1740: $2800''\, F = 0''.277 \sin (122^\circ\, 20' + \odot)$

Relative to the term $0''.115 \sin [336^\circ\, 59' + (t \pm i\, 18^y.61)\, 19^\circ\, 20'.5]$ it is to be remarked, that the year 1840, from which t is reckoned, is about in the middle of that part of the draconistic period when occultations of the Pleiades possibly can take place. And as this part does not extend over much more than four years, $t \pm i\, 18^y.61$ will always be between the limits $\pm$ 2 years; consequently the angle under the *sine* between 298° 18′ and 375° 40′, that is to say, the term depending on the moon's node, cannot exceed 0″.11, and will be in most of the cases nearer to 0.00, as shown here below:

$t \pm i\, 18^y.61$	F.	y	F.	y	F.	y	F.	y	F.
y	″		″		″		″		″
− 2.5	− 0.12	− 1.5	− 0.10	− 0.5	− 0.07	+ 0.5	− 0.03	+ 1.5	+ 0.01
2.4	0.12	1.4	0.09	0.4	0.06	0.6	0.02	1.6	0.02
2.3	0.11	1.3	0.09	0.3	0.06	0.7	0.02	1.7	0.02
2.2	0.11	1.2	0.09	0.2	0.06	0.8	0.02	1.8	0.02
2.1	0.11	1.1	0 09	− 0.1	0.05	0.9	0.01	1.9	0.03
2.0	0.11	1.0	0.08	0.0	0.05	1.0	0.01	2.0	0.03
1.9	0.11	0.9	0.08	+ 0.1	0.04	1.1	0.00	2.1	0.04
1.8	0.10	0.8	0.08	0.2	0.04	1.2	+ 0.00	2.2	0.04
1.7	0.10	0.7	0.07	0.3	0.04	1.3	0.00	2.3	0.04
1.6	0.10	0.6	0.07	0.4	0.03	1.4	0.01	2.4	0.05
− 1.5	− 0.10	− 0.5	− 0.07	+ 0.5	− 0.03	+ 1.5	+ 0.01	+ 2.5	+ 0.05

where $F = 3000''\, (5.6129) \sin. [336^\circ\, 15' + (t \pm i\, 18^y.61)\, 19^\circ\, 20'.5,]$ so that by taking F from this table, the correction of the co-ordinate x_s or y_s depending on this term is equal to $\frac{y_s}{3000} F$, or $-\frac{x_s}{3000} F$.

For the other terms, depending on the sun's longitude, similar small tables may be constructed, having the day of the year as argument, so that it may be seen immediately whether the correction is at all sensible or not in the tenth of the second. Also those stars, of which one or both of the co-ordinates are so small, that the correction remains always under the assumed limit of accuracy, may be marked with an asterisk.

11. The co-ordinates of the Pleiades have been computed for the year 1840 by myself, and also by Mr. Webber. My computations are made by the formula of § 6, and are contained in the accompanying paper (A.) Mr. Webber's computations have been made by a slightly dif-

ferent formula, which I had given him. I have examined and corrected them, and they are contained in the two sheets marked (A¹).*

The following are the places of the stars, with their co-ordinates for 1840:

Name of Star.	Magnitude.	α^1	β^1	x_s	y_s	Proper motion. In x_s	Proper motion. In y_s
		° ′ ″	° ′ ″	″	″		
16 *g* Celæno	5.6	53 49 33.64	23 46 49.58	— 2208.22	637.85	.027	— .010
17 *b* Electra	4.5	50 47.59	36 16.24	— 2143.43	4.19	.006	.006
18 *m*	7	54 25.52	24 19 52.36	— 1932.88	2619.52	— .023	
19 *e* Taygeta	5	55 26.47	23 57 34.12	— 1882.75	1281.01	— .005	.010
Anonyma 1	8	59 14.52	31 42.30	— 1679.88	— 271.63		
2	8.9	54 0 55.25	57 25.09	— 1582.33	1270.86		
3	9	1 30.81	34 36.65	— 1554.35	— 97.70		
4	8	1 52.66	49 45.23	— 1531.36	810.82		
5	9	2 11.22	24 7 16.14	— 1510.98	1861.69		
6	9	2 49.03	23 46 57.30	— 1480.33	642.72		
20 *c* Maja	5	4 46.31	51 43.12	— 1372.17	928.22	.010	.006
A. 7	8	5 35.15	32 00.41	— 1330.84	— 254.63		
21 *k* Asterope	7.8	5 48.99	24 2 56.40	— 1312.95	1601.34	.027	.011
22 *l*	7.8	7 56.33	1 21.97	— 1196.91	1506.60	— .009	.014
A. 8	8.9	10 56.98	23 41 26.35	— 1034.54	310.58		
9	8.9	11 31.24	41 07.91	— 1003.20	292.07		
23 *d* Merope	5	12 37.28	26 39.23	— 944.46	— 576.74	.045	.008
A. 10	8	14 15.83	45 04.35	— 852.05	528.21		
11	8.9	17 24.71	36 00.60	— 679.95	— 15.82		
12	7.8	22 01.14	24 1 04.70	— 425.27	1488.00		
13	8.9	23 41.65	23 29 37.12	— 334.81	— 399.67		
14	9	25 11.96	15 52.45	— 252.42	— 1224.39		
15	8.9	26 39.14	37 37.49	— 171.85	80.61		
16	9.10	26 58.66	18 58.24	— 154.34	— 1038.64		
17	8	27 18.67	13 29.57	— 136.05	— 1367.33		
18	8	27 20.05	38 16.98	— 134.36	120.09		
24 *p*	7.8	27 46.26	36 55.12	— 110.37	38.22	— .009	
A. 19	8	28 01.82	18 09.11	— 96.34	— 1087.79		
20	8	28 05.46	24 5 15.46	— 92.44	1738.56		
21	8.9	28 41.90	9 22.06	— 59.14	1985.17		
22	8	28 47.57	23 24 50.13	— 54.28	— 686.78		
23	8.9	29 36.40	10 40.14	— 9.49	— 1536.78		
24	8	29 42.52	47 16.49	— 3.84	659.58		
25 *η* Alcyone	3 4	29 46.72	36 16.91	0	0		
A. 25	8 9	32 05.30	6 35.59	+ 127.46	— 1781.31		
26	9	33 36.76	2 35.89	211.69	— 2020.99		
27	8.9	40 39.14	49 12.64	596.85	776.11		
28	7	43 17.17	22 55 25.93	746.47	— 2450.43	— .022	.007
29	8	44 45.04	23 50 53.36	821.63	877.16	0	
26 *s*	7.8	51 48.27	21 43.53	1213.22	— 871.83	— .017	
27 *f* Atlas	4.5	54 53.68	33 30.41	1381.36	— 164.48	— .007	— .009
28 *h* Plejone	5.6	55 10.82	38 30.60	1396.18	135.75	— .013	— .017
A. 30	8.9	55 39.24	23 31.50	1424.93	— 763.27		
31	8	56 20.32	54 04.70	1456.96	1070.06		
32	8	57 35.11	53 11.52	1525.50	1017.09		
33	8.9	58 45.54	45 12.36	1591.53	538.13		
34	7.8	55 3 36.72	13 07.69	1865.61	— 1385.57		
35	9	3 47.46	45 02.15	1867.91	528.94		
36	9	5 59.14	43 26.57	1988.85	433.86		
37	8	6 17.63	51 22.51	2003.75	909.88		
38	8	7 06.69	21 22.86	2056.44	— 889.60		
39	8	13 58.00	24 00 13.63	2422.04	1443.00		
A. 40	7.8	20 31.97	23 28 18.94	2793.30	— 469.74		

12. The values of *h* and *k* for the principal observatories have been computed by me, and the computations are contained in the accompanying paper (B,) which also contains a general table for sec. ψ.* The values of *h* and *k* have also been computed by Mr. Webber, and his computations, corrected by me, are contained in (B¹).* The data for this computation are taken from

* Omitted.

the list of latitudes and longitudes furnished by Dr. GOULD to the American Ephemeris and Nautical Almanac of 1856.

The following are the values of h and k for these observatories:

Name of observatory.	log. h.	log. k.
Abo	9.6941197	9.9376798
Altona	9.7748568	9.9034777
Athens	9.8972462	9.7867235
Berlin	9.7853155	9.8975097
Bilk	9.7978101	9.8897522
Bonn	9.8026252	9.8868042
Breslau	9.7986681	9.8891922
Brussels	9.8011183	9.8875732
Cambridge, (England)	9.7881613	9.8958059
Cambridge, (Massachusetts)	9.8691219	9.8264510
Cape of Good Hope	9.9193626	9.7443749 n
Christiania	9.7012096	9.9353351
Cincinnati	9.8904755	9.7974697
Copenhagen	9.7521119	9.9150283
Cracow	9.8083436	9.8826154
Dorpat	9.7206227	9.9283612
Dublin	9.7764794	9.9025810
Durham	9.7620565	9.9102012
Edinburgh	9.7490484	9.9164507
Florence	9.8592479	9.8378187
Geneva	9.8409549	9.8562485
Georgetown, D. C.	9.8916436	9.7956765
Göttingen	9.7947543	9.8917171
Gotha	9.8003573	9.8880791
Greenwich	9.7952551	9.8913980
Hamburgh	9.7747951	9.9035115
Hudson	9.8767884	9.8165040
Kasan	9.7509089	9.9155904
Königsberg	9.7626391	9.9099083
Kremsmünster	9.8258374	9.8693645
Leipsic	9.7965643	9.8905587
Leyden	9.7887124	9.8954718
Liverpool	9.7762115	9.9027297
London	9.7948021	9.8916867
Madras	9.9886767	9.3515303
Mannheim	9.8134999	9.8789018
Markree	9.7683373	9.9067776
Marseilles	9.8627005	9.8339690
Milan	9.8466551	9.8508346
Modena	9.8258539	9.8446192
Moscow	9.7512895	9.9154129
Munich	9.8250859	9.8699736
Naples	9.8793021	9.8134579
Olmütz	9.8125472	9.8795999
Oxford	9.7925577	9.8931026
Padua	9.8471626	9.8503388
Palermo	9.8964192	9.7880831
Paramatta	9.8199721	9.7430133 n
Paris	9.8191833	9.8746266
St. Petersburgh	9.7008247	9.9354650
Philadelphia	9.8851572	9.8053345
Prague	9.8081215	9.8827719
Pulkowa	9.7030364	9.9347141
Rome	9.8724136	9.8224026
San Fernando	9.9059015	9.7716174
Santiago	9.9218469	9.7387465 n
Senftenberg	9.8081426	9.8827571
Vienna	9.8245451	9.8704094
Washington, D. C.	9.8917229	9.7955541
Wilna	9.7629694	9.9097416

APPENDIX No. 25.

Report to the Superintendent of the Coast Survey, by Dr. C. H. F. Peters, on the method of substituting a lunar spot instead of the moon's limb, in transits for determining the difference of longitude.

DUDLEY OBSERVATORY, *Albany, November* 28, 1856.

DEAR SIR: I have the honor to submit to you the following report respecting some trials undertaken by your order, with the view of ascertaining the practicability and the advantage of using a lunar spot in transit observations for the determination of longitude.

Among the astronomical methods for determining differences of longitude, that by *moon-culminating stars* recommends itself to the observer by its speediness and simplicity. It was recognized as such by the principal astronomers, at the time when *Schumacher* began to publish his valuable "Astronomische Nachrichten," and was introduced at once into practice at nearly all the European observatories. As it promised the great advantages of avoiding the troublesome parallax and the uncertain refraction, of eliminating the errors of star positions, and of not requiring the absolute right ascension of the moon, but her motion only—the attention paid to this method for more than thirty years past, both by the editors of Ephemerides and by observers, seemed completely justified. But as soon as American observatories also entered the field, and as the United States Coast Survey demanded longitudes not inferior in accuracy to those of established observatories, that which for the range of Europe has been but one method amongst many for determining the difference of longitude, became very valuable and almost indispensable for linking the establishments in countries on either side of the ocean. Discrepancies in the results, however, now came to light, and inconveniences in the method, which, within the meridian limits of Europe, might be considered insensible or of no consequence. With the distance increased the uncertainty of obtaining corresponding observations; the tangent point of the lunar disk observed in transiting, falling upon regions too distant, brings in the full weight of the irregularities of shape, which our satellite is known to possess in considerable degree; and the moon's motion, the only theoretical element entering into the problem, can no longer be considered as exactly ascertained, when the question concerns wide geographical limits. *Professor Peirce* has shown (U. S. Coast Survey Report, 1854) how to lessen the influence of this element, by correcting the lunar ephemeris from a series of culminations observed at the standard meridians, at the same time rendering available all the observed transits, instead of the strictly corresponding ones alone. But even with this improvement, he has found discrepancies in the results greater than those affecting the telegraphic and other determinations of difference of longitude. These are attributable to the method itself, and to the probable error of the observations which form the foundation of it. As bearing directly on this point, the remark, pronounced by the same learned authority, viz: that any number, however great, of observations, cannot diminish the probable error of the mean beyond a certain limit,* seems to leave no hope of obtaining the desired accuracy but by changing the mode of observation itself.

The principal cause of error lies in the observation of the transit of the moon. This is deduced from the transit of a limb, subject, as is well known, to two errors—a probable error, considerably larger than in the transit of a star; and a constant error, depending on the apparent semi-diameter. Even if the outline of the lunar disk did not present irregularities, already referred to, it is still not so easy to bring the wire tangent to a circle as to pass it over a luminous point; and, moreover, the effect of the brightness of the disk on the retina, united with the agitation of the atmosphere, produces a swelling undulation in the apparent limb.

* "There is in every species of observation an ultimate limit of accuracy, beyond which no mass of accumulated observations can ever penetrate."—*Coast Survey Report*, 1854, *p.* *109.

The irradiation, also, whether in the telescope or in the eye of the observer, the personal judgment in regard to the division between dark and light, and the particular state of the atmosphere, combine to introduce an error, which is, to a certain extent, constant. To eliminate this, it has been the custom to take the mean between results from observations of the first and second limbs, whereby, however, the labor is at least doubled, and the chance of obtaining corresponding observations of course diminished in proportion. Besides, a supposition is involved which seems not justifiable, viz: that the constant error is really the same in amount, only contrary in sign, for the first and second limbs of the moon; and, not to speak of other objections, it certainly seems reasonable to suppose the judgment in respect to contact to be influenced differently according as the dark or the light part of the field is preceding. Sometimes, also, it has been the practice to determine beforehand the particular correction to be applied, or the apparent diameter of the moon belonging to a given telescope, by observations at a station of known longitude. But this mode—the only one suitable, for example, for travellers who seldom remain at one and the same place during an entire lunation—even if we admit the correction to be constant, requires a series of preparatory observations not always feasible.

It appears from the foregoing, that, if the method of using moon-culminating stars be at all susceptible of sufficient improvement to satisfy the claims made now-a-days for more accurate geographical longitudes, and if perfection is sought for in the mode of observation, the first step ought to be to abandon the system of observing the moon's limb. Twenty-five years ago, Mædler* proposed to substitute, in transits, a lunar spot instead of the moon's limb, and even indicated several spots which seemed the most suitable for the purpose. This idea, however, had never been carried into practice, until you, upon the suggestion of Professor Peirce, who, with his usual sagacity, fully recognised its utility, directed some trials to be made at the Cloverden Observatory, the general results of which I have here the honor to submit, together with some remarks in regard to the manner both of observation and of computation. Professor Bond had the kindness to make some corresponding observations at Harvard Observatory.

The selection of the spots to be observed is necessarily regulated by the size and magnifying power of the instrument. Their apparent area should not be too large, (which might give rise to constant error;) and, on the other hand, they ought to be clear and distinct enough to be followed easily with the eye. Too great a difference between the telescopes, (as, for example, between the large transits of the observatories and the telescope of a theodolite,) therefore, would not be admissible. From actual experiments made at Cloverden, I am induced to conclude that $\frac{600}{m}$ seconds is nearly the upper limit of extension of a spot to be selected for a telescope of magnifying power m. The white and small star-like craters are the most convenient, being less subject to change of apparent form and illumination by the age of the moon. Those situated in a plain, (*mare*,) isolated from surrounding mountains, are best suited to the purpose, especially if easily recognizable by some peculiarity. Otherwise, the eye, removed from the telescope between each pair of wires for the instant requisite to note the time, loses its steadiness by searching for the right spot. These conditions are admirably combined in the spot *Messier*; the comet's tail, which stretches from it to the borders of the *Mare Fœcunditatis*, affording an excellent characteristic. It has the advantage of being visible from the 4th to the 17th day of the moon; appearing in the Cloverden transit (U. S. C. S. No. 4) like a small planetary disk, white on dark ground: it has been the principal object of observation.

The researches undertaken, I supposed, should resolve these two questions:

1. What is the *probable* error in the transit of a spot, properly selected in relation to the telescope?

2. Do the transits of spots give rise to *constant* errors in the longitudes deduced therefrom?

In regard to the first question, the result is perfectly satisfactory. From a great number of

* In an article entitled, "On the general use of the lunar map," in Schumacher's Ast. Nach., No. 337.

observations made on several spots, I deduce the *probable error* of a lunar spot transit over one wire in the Cloverden instrument to be $0^s.073$, whilst I find for a star, situated within the limits of the zodiac, a *probable error* of $0^s.080$. Whence we may infer, that the transit of a well-conditioned spot is at least as accurate as that of a fixed star. Indeed, the spot is seen gliding over the wire with a pleasing steadiness, so that its position at the clock-beat can be seized with much greater precision than the transit of the undulating limb of the moon. I should remark that these values have been derived from the deviations of the single wires from the mean of seven. And this is, in fact, the *complete* value of the error, no other sources entering, provided that the moon-culminating stars be treated as originally designed; that is to say, if the differences only of the moon from stars identical at both stations be considered, and computed by means of the moon's motion, without involving absolute right ascensions. The mean of seven wires will have the *probable error* of $0^s.029$, both for moon and star, and the difference of right ascension thus determined is $0^s.041$. Supposing, then, the observations at both stations to be equally accurate, $0^s.058$ will be the *probable error* of the element, which, in the computation of the longitude, is contributed by observation, if the result given by one star is compared with that deduced from the transit of a spot. This will produce, with the moon's mean motion, an error of $1^s.57$ in geographical longitude. As the accuracy is increased by taking, as usual, several comparison stars, so the use of the chronograph, instead of the ear and eye, might be of particular advantage in observing these transits, by permitting several spots to be observed during the same transit of the moon.

The actual determination of a known difference of longitude offers certainly the best trial of the method by lunar spots, since, by a series of such determinations, we may ascertain directly its reliableness, in regard both to *probable* and to *constant* error, though the clue to the sources of these, and consequently to an improvement of the method itself, is to be sought for in investigations upon the elements proper, which concur to the result. The best thanks, therefore, are due to the estimable Director of Harvard Observatory, who, notwithstanding his occupation in the duties of the Observatory, at my request, kindly undertook to observe corresponding transits of the spot *Messier* with the Harvard meridian circle. In the expectation of a more extended series of trials, (to be entered upon as soon as the arrangements at the Dudley Observatory are completed,) I deem it sufficient to transcribe here only the results, which the few corresponding observations between Cloverden and Harvard Observatories have furnished for the difference of longitude, by means of the spot above named. They are the following:

	West longitude. H.—C.	Number of comparison stars.
	s.	
1855—June 27	+ 1.30	1
Nov. 20	5.47	3
Dec. 17	3.64	4
1856—May 14	3.56	2
June 16	3.52	4
July 15	3.71	3

These, on the whole, agree very well together, considering that on June 27, only one comparison star was observed, identical at both stations. The mean is $+ 3^s.54$, Harvard Observatory west of Cloverden. According to a communication from Dr. B. A. Gould, jr., the true difference of longitude between the two observatories, as resulting from an exact geodetic survey, is only $+ 1^s.65$. The difference of nearly two seconds, which is here found by the lunar spot culminations, shows clearly a startling *constant error*. What may be the cause of this, cannot well be decided, except by a longer series and a more systematic arrangement of the corresponding observations. Although, at Harvard Observatory, Professor Bond observed by the electric method, and I, at Cloverden Observatory, only with the ear and eye, it seems hardly possible that any personal equation should have remained, as this must have been eliminated in the right ascensional difference of star and spot. Neither does it seem probable, that in a spot so neatly round and circular as *Messier*, the observers, on account of the great diversity of the two telescopes, should have judged the precise point of observation different by the amount of 1″.05, the whole diameter of the crater of *Messier* being no more than 8″. Still, this may, perhaps, be a question to be settled only by corresponding observations upon spots of various sizes. In a case like the present, where the two stations are so near together, the computation of longitude from transits of spots is extremely simple, since, for so short an interval of time as passes between the transits at the two meridians, the motion in right ascension of the spot is sensibly equal to that of the moon's centre. But, as the method of spot transits may yet be found to be superior to that of transits of the limb, and eventually supersede it, permit me to develop the formulæ required additional to the usual ones employed, and adapted to any distance of the meridians.

The computation of lunar-spot culminating stars differs from that of moon culminating stars evidently only in that, whilst in the latter the point of contact observed is connected with the centre of the moon's disk in a very simple and, as the tangent to a sphere, constant way; in the former, the same has a variable relation, because of the libration and of the parallactic displacement of the spot. Nothing is required, therefore, but the expressions for the differences of the spherical co-ordinates (right ascension and declination, or azimuth and zenith distance) of spot and moon's centre for any given moment, or, properly, nothing but the hourly motion of these differences.

The position of a spot upon the moon is given by its selenographical longitude l' and latitude b', the former counted from the *first* lunar meridian, being positive to the *west*. By the term *first* is understood that meridian which passes through the lunar radius, directed towards the earth's centre at the moment when the line of the node of the lunar equator upon the ecliptic coïncides both with that radius and with the mean longitude of the moon. In order to find the position of the spot relative to the earth at any given time, it is necessary to know what point on the moon's surface, at that time, is directed towards the earth, or, in other words, the libration of the moon's centre—that is, the selenographical longitude l and latitude b of the point mentioned. As to principal terms, these are expressed as follows:

$$l = \lambda - l_0 + 34''.4 \sin 2\,(\lambda - \Omega) + b \cos(\lambda - \Omega) \sin \mathrm{I}$$
$$b = \mathrm{B} - \beta$$

where $\tan \mathrm{B} = -\sin(\lambda - \Omega) \tan \mathrm{I}$ and λ, β the geocentric longitude and latitude of the moon's centre, l_0 the mean longitude of the moon, Ω the longitude of the ascending node of the moon's orbit upon the ecliptic, (always coincident with the descending node of the moon's equator upon the ecliptic,) I the inclination of the moon's equator to the ecliptic, (= 1° 28′ 47″ according to *Nicollet* and *Bouvard*, 1° 32′ 09″ according to *Wichmann's* recent determination with the Königsberg Heliometer.) For the terms containing trigonometrical functions, *Encke* has given tables (Berliner Astr. Jahrb. 1843) by means of which the quantities l and b are obtained with great ease.

These formulæ hold for any point upon the earth, if we substitute in them, for λ and β, the longitude and latitude of the moon's centre as seen from the same point. I shall show how libration and parallax may very conveniently be taken into account conjointly. Bessel uses, in his method for the reduction of lunar distances, a process, for including the parallax, which seems at once the most simple and the most complete, viz: by referring the co-ordinates of the moon to that point of the earth's axis where this is intersected by the prolongation of the line of direction of gravity at the place of observation. If η be the distance of the point of intersection (which, for brevity sake, I shall call the *nadir point*) from the earth's centre, readily computed by the formula—

$$\eta = \rho \frac{\sin(\varphi - \varphi')}{\cos \varphi}$$

or by $\sin \psi = e \sin \varphi$ and $\eta = e \tan \psi$, e being the eccentricity of the terrestrial meridians, φ and φ' the astronomical and geocentric latitudes, and ρ the earth's radius for the place; if, moreover, α, δ be the moon's geocentric right ascension and declination for the given instant, π her equatorial horizontal parallax, then the declination at the nadir point will be

$$\delta' = \delta + \eta \pi \cos \delta,$$

while the right ascension remains unchanged. The distance of the moon's centre from the nadir point r is expressed by

$$\log r = M \eta \sin \pi \sin \delta$$

M being the modulus of the Brigg. logarithms. Now, by converting the right ascension and declination (α and δ^1) into longitude and latitude λ, β (which, with sufficient accuracy, may be done by means of auxiliary tables found in several books,) and computing l and b, we have the libration appertaining to the point M upon the moon's surface, in the line drawn from the moon's centre to the nadir point; and, from the relations in the spherical triangle at the moon's centre between the point M, the lunar north pole and the spot, results:

$$\begin{aligned} \cos m &= \sin b \sin b' + \cos b \cos b' \cos (l' - l) \\ \sin m \cos \mathrm{M} &= \cos b \sin b' - \sin b \cos b' \cos (l' - l) \\ \sin m \sin \mathrm{M} &= \cos b' \sin (l' - l). \end{aligned}$$

Whence we derive M the solid angle formed by the planes passing through the nadir point, lunar centre and lunar pole, and through the nadir point, lunar centre and spot, and m the angle at the centre of the moon between the nadir point and spot. The rectilinear triangle formed by the nadir point, spot and lunar centre, gives also, the angle at the nadir point being denoted by n, the distance of the nadir point from the spot by r', and the ratio of the moon's radius to the earth's by k ($= 0.2725$):

$$\begin{aligned} r' \sin n &= k \sin \pi \sin m \\ r' \cos n &= r - k \sin \pi \cos m. \end{aligned}$$

It remains to refer the position of the lunar north pole, from which the angle M is reckoned, to some known circle. For this, we find in the astronomical ephemerides the quantities:

i = the inclination of the moon's equator to the earth's equator.

Δ = the angle in the moon's equator, counted from the ascending node upon the earth's equator to the ascending node upon the ecliptic.

Ω' = the ascending node of the moon's equator upon the earth's equator.

The angle C, intercepted by the lunar meridian passing through M and the hour circle is immediately obtained from either of the following equations:

$$\begin{aligned} \sin \mathrm{C} &= \sin i \frac{\cos (l + l_\circ - \Omega + \Delta)}{\cos \delta'} \\ &= - \sin i \frac{\cos (\alpha - \Omega')}{\cos b} \end{aligned}$$

The angle C is considered *positive*, if the northern part of the hour circle, in looking towards the moon, appears to the *west* of said lunar meridian; and, as it is always $< 90°$, there cannot be any ambiguity on account of the determination by the sine. From this we have now the angle of position of the spot

$$\mathrm{N} = \mathrm{M} - \mathrm{C},$$

whence, in combination with the angular distance from the moon's centre n and the linear distance r', the position of the spot relative to the nadir point becomes completely known.

So far the formulæ are common to every kind of transits of lunar spots, and are applicable as well to observations of right ascension and declination as to measures in any azimuth and zenith distance. For the application to transits at the meridian, we have the relations

$$\begin{aligned} \sin \delta'_1 &= \sin \delta' \cos n + \cos \delta' \sin n \cos \mathrm{N} \\ \cos \delta'_1 \cos (\alpha - \alpha') &= \cos \delta' \cos n - \sin \delta' \sin n \cos \mathrm{N} \\ \cos \delta'_1 \sin (\alpha - \alpha') &= \sin n \sin \mathrm{N} \end{aligned}$$

of which we need only the combination of the last two, viz:

$$\tan(\alpha - \alpha') = \operatorname{cosec} \delta' \frac{\tan \delta' \tan n \sin N}{1 - \tan \delta' \tan n \cos N}$$

from which α' or the right ascension of the spot relative to the nadir point is found. But, since in the meridian the parallax in right ascension is zero, α' is, at the same time, the *apparent* right ascension of the spot, which is the element required for computing the longitude from spot transits.

The further development, which the above formulæ need for their practical application, as well as the simplification of them by developing in series, I reserve for the report on the trials next to be undertaken at distant meridians. If these trials succeed in re-establishing the credit of the method of moon-culminating stars, the complexity of the computations will be fully compensated by the exactness of the results in the determination of the longitudes of many places between the Atlantic and the Pacific, yet beyond the reach of the magnetic telegraph.

All of which I submit.

Very respectfully,

C. H. F. PETERS.

Prof. A. D. Bache, LL. D.,
Superintendent U. S. Coast Survey.

APPENDIX No. 26.

Report of Assistant George Davidson upon observed occultations of α Scorpii and of the planet Mars, at Point Hudson, Port Townshend, Washington Territory, in April and May, 1856.

United States Brig R. H. Fauntleroy,
Admiralty Inlet, Washington Territory, May 17, 1856.

Dear Sir: Enclosed please find copies of the observations relating to the occultation of α Scorpii, April 22, and of Mars, May 14.

* * * * * * * * *

Astronomical station at Point Hudson, Port Townshend, Washington Territory, April 22, 1856.

Observations for error of sidereal chronometer Hutton 231, and for instrumental errors.

Portable transit No. 7, by Würdemann.

Value of one division of the level scale = 0.0955 seconds.

The following observations were made in connection with the observation of the occultation of α Scorpii. On account of the very cloudy weather, the transit instrument had not been put in the meridian.

To-night several stars culminating near the zenith were sought for, but not seen on account of clouds. With the instrument near the meridian by estimation, the transit of B. A. C. 3981= G. C. 969, very near the zenith, was at last observed for the approximate error of the chronometer, and gave it slow 1*h.* 05*m.* 45.4*s.* I then reduced the A. R. of B. A. C. 4050, 4070, and 4150=1004 G. C., (having small N. P. D.'s,) to date, and with the above error of the chronometer obtained their times of culmination. The first was not seen on account of clouds; second was seen faintly; at the computed time of culmination of the third the star was bisected by the middle wire of the transit; axis nearly level; little or no error of collimation. Then commenced observing for time, &c., clouds gradually breaking away, and wind (from S.S.E.) increasing.

Astronomical station at Point Hudson, Port Townshend, W. T., April, 1856.

Date	22d.	22.	22.	22.	22.	22.	22.	22.	22.	22.	22.
Object Description	969 G. C.	β Corvi th. clds. m-unst.	γ Virginis m-st.	12 Can. Ven. l. unst.	1049 G. C. m-unst.	α Virginis l. m-unst.	1077 G. C. m-st.	η Ur. Maj. m-st.	Observed the disappearance of α Scorpii behind the bright limb of the moon, at *13h. 40m. 02.3s.*	α Cor. Bor. th-clds.	α Serpentis th-clds.
Illumination Chronometer Observer	East. 231 D.	East. 231 D.	East. 231 D.	East. 231 D.	West. 231 D.	West. 231 D.	West. 231 D.	West. 231 D.		West. 231 D.	West. 231 D.
	E. W.										
Level	13. 4 26. °5	27. °2 12. 9	....	18. 2 21. °5	26. °1 14. 7	17. °6 25. 7	26. °1 18. 5	19. 0 25. °5		29.4 17.0	....
"	20. °6 19. 2	18. 8 21. °2	....	25. °2 12. 9	17. 0 25. °1	26. 2 17. °8	19. 0 25. °5	25. °2 17. 8		21. 2 25. 0	....
	h. m. s.										
Wires	31 07. 6	19 57. 8	....	42 13. 1	55 42. 8	10 48. 7	21 13. 6	34 31. 5		21 40. 7	30 23. 2
	31 39. 1	20 20. 7	....	42 40. 1	56 04. 2	11 10. 4	21 46. 6	35 03. 9		22 04. 6	30 44. 5
	32 10. 7	20 43. 5	28 17. 3	43 07. 5	56 25. 0	11 31. 3	22 18. 6	35 36. 4		22 28. 0	....
	10 32 42. 6	11 21 06. 2	11 28 38. 5	11 43 34. 6	11 56 45. 8	12 11 52. 5	12 22 51. 1	12 36 08. 7		14 22 51. 7	14 31 26. 3
	33 14. 7	21 28. 9	28 59. 2	44 01. 6	57 06. 8	12 13. 9	23 23. 2	36 41. 3		23 15. 0	31 47. 2
	33 45. 6	21 51. 2	29 19. 8	44 27. 6	57 28. 1	12 35. 3	23 55. 6	37 14. 2		23 38. 8	32 08. 6
	(a) 34 17 6	22 14. 1	29 41. 3	44 55. 3	57 49. 2	12 56. 6	24 28. 5	37 47. 0		24 02. 2	32 29. 7
Sums											
Means											

(*a*) Instrument levelled after this observation and moved in azimuth, with tangent screw to follow the close circumpolar stars.

Astronomical station, Point Hudson, Port Townshend, Washington Territory, April 22, 1856.

Remarks upon occultation of α Scorpii.

Wind S.S.E. moderately fresh, but telescope much sheltered by the observatory.

With C. S. Recon. Tel. No. 18, and astronomical eye-piece with an estimated power of about 70, observed the disappearance of α *Scorpii* behind the bright limb of the moon at

13*h*. 40*m*. 02.3*s*., by Sid. Chro. 231.

For error of chronometer see previous observations.

This time denotes the instant of the disappearance of the star after it had been projected upon the body of the moon for about 2½ seconds, certainly not less. The ruddy color of the star showed distinctly upon the body of the moon, and the instant of its disappearance was as accurately noted as if it had disappeared behind the dark limb.*

It was hoped to obtain the reappearance and also the transit of the moon, star, and culminating stars, but the wind, which had been increasing, brought up dense clouds and a S.S.E. squall and rain.

Astronomical station at Point Hudson, Port Townshend, Washington Territory, May, 1856.

Observations for error of sidereal chronometer 231, and for instrumental error.

Portable transit No. 7, by Würdemann.

Value of one division of the level scale = 0.0955 seconds.

The following observations were made in connection with the observation of the occultation of *Mars*.

May 13. Error of chronometer brought up by last determined rate. Set for and observed transit of 3812 B. A. C. and δ Leonis, and found rate of chronometer changed and instrument much out of the meridian, but the first star being near the zenith assumed error of chronometer =1*h*. 06*m*. 55*s*. slow. Computed culmination of B. A. C. 3953 and 3981—the one north and the other south of the zenith about ½°—and observed their transits. The former gave error of chronometer = —1*h*. 06*m*. 54.2*s*., and the latter —1*h*. 06*m*. 54.4*s*., both uncorrected for inclination of transit axis, which was not quite in adjustment. With this error of chronometer computed the culmination of 4050, and bisected the star with the middle wire at instant of culmination. The star was *very faint;* tried to see 4070 and 4150 but could not, as the clouds were too thick and increasing ; assumed the instrument in the meridian and commenced observing standard stars.

It will be found that the chronometer has gone back to its old stationary rate, which was 3.30*s*., losing daily.

* Having once before observed this same appearance, I was fully prepared for it.—G. D.

Astronomical station at Point Hudson, Port Townshend, Washington Territory, May, 1856.

Date	13.	13.	13.	13.	13.	13.	13.	14.
Object Description	β Corvi. m-st. th. thk-clds.	γ Virginis. d. m-st. th-hz.	12 Can. Ven. d. st. th. thk-hz.	1049—4401. r-ft. th-hz.	α Virginis. l. dif. m-unst.	1077—4538. m-d. m-st.	η Ursæ Majoris. l. d. m-st.	
Illumination Chronometer Observer	West. 231 D.	West. 231 D.	West. 231 D.	East. 231 D.	East. 231 D.	East. 231 D.	East. 231 D.	The thick clouds obscuring the sky prevented any attempt to get the instrument nearer the plane of the meridian than by last night's observations. The azimuth screw moves so unevenly that no reliance can be placed upon it.
Level "	22.4 22.8 20.0 25.5	21.6 24.0 23.7 21.8	23.9 21.8 20.7 24.8	22.0 24.0 26.6 19.6	26.6 19.6 22.7 23.3	27.1 18.4 25.2 21.6	21.7 25.8 25.8 21.3	
Wires	*h. m. s.* 18 49.7 19 12.6 19 34.8 11 19 57.6 20 20.6 20 43.2 21 6.1	26 27.2 26 48.3 27 09.0 11 27 29.7 27 50.7 28 11.8 28 32.8	41 04.4 41 31.7 41 58.2 11 42 25.4 42 52.4 43 19.5 43 46.6	too ft. 55 16.7 11 55 37.5 55 58.7 56 19.5 56 40.7	9 40.6 10 01.9 10 23.2 12 10 44.5 11 05.7 11 27.1 11 48.6	20 05.9 20 38.0 21 10.5 12 21 42.7 too ft. 22 47.3 23 19.9	33 22.5 33 54.8 34 27.5 12 35 00.2 35 33.1 36 05.2 36 38.1	
Sums								
Means								

Astronomical station at Point Hudson, Port Townshend, Washington Territory, May, 1856.

Date	14.	14.	14.	14.	14.	14.	14.	14.	14.	14.
Object Description	α Ursæ Majoris. v-ft. th-clds.	δ Leonis. m-d. m-st.	τ Leonis. ft. m-st.	γ Ursæ Majoris. ft. th-clds.	I Moon. v.ft.th thk.clds	Contact of 1st limb of Mars with dark limb of moon = 15*h*. 18*m*. 1.3*s*., by chronometer 231.	1345.	ε Ur. Minoris.	Star having an alt. of 67° 34′.	1526
Illumination Chronometer Observer	East. 231 D.	East. 231 D.	East. 231 D.	East. 231 D.	East. 231 D.		East. 231 D	East. 231 D	East. 231 D.	East. 231 D.
Level "	17.7 22.°8 ----------	---------- 25.°6 15.9	26.°1 16. 1 19. 5 22.°8	20. 4 22.°5 27.°0 16. 2	28.°0 16. 8 19. 4 24.°8	Disappearance of 2d limb of Mars behind dark limb of moon, = 15*h*. 18*m*. 26.7*s*., by chronometer 231.	22. 0 24. 4 30. 4 16. 0	22. 4 22. 2 30. 5 14. 5	---------- ----------	32. 2 16. 8 24. 8 23. 8
Wires	*h. m. s.* -------- 46 22. 5 47 08. 3 9 47 53. 6 48 39. 2 49 23. 5 50 09. 9	58 23. 6 58 46. 5 59 09. 1 9 59 31. 4 59 54. 1 60 16. 2 60 38. 9	12 33. 4 12 54. 5 13 15. 6 10 13 36. 5 13 57. 6 14 18 3 14 39. 4	-------- 38 07. 6 -------- 10 ------- 39 56. 1 40 31. 9 1 ----	-------- -------- -------- 10 58 44. 6 59 06. 0 59 26. 8 59 48. 6	Separation of the 2d limb of Mars from the moon's bright limb, by chronometer 231, at 16*h*. 24*m*. 15.5*s*.	2 44. 2 3 05. 3 3 26. 3 15 03 47. 2 4 08. 3 4 28. 9 4 50. 4	-------- -------- 51 26. 7 15 54 02. 2 56 38. 0 -------- --------	6 12. 2 6 35. 6 6 58. 8 16 07 22. 1 7 45. 5 8 08. 4 8 32. 1	28 22. 6 28 43. 9 29 04. 8 16 29 26. 1 29 47. 3 30 07. 6 30 29. 2
Sums										
Means										

Very dense clouds prevented further observations.
A complete list of moon culminating stars had been made out, but the above were all that could be obtained.

At the contact of the I limb of Mars, with the dark limb of the moon, the planet was hazy and moderately unsteady.

The observed time of the disappearance of the II limb of Mars behind the moon's dark limb is the most reliable of all the observations.

At the separation of the II limb of Mars from the bright limb of the moon, both objects were seen through a thick hazy stratum of clouds, and the moon's was very unsteady.

The appearance of Mars was gibbous ; the 1st limb well defined.

At the time of the disappearance of 13 Virginis the moon was hidden by dense clouds ; and at its reappearance from the bright limb it could not be seen, and was not for some time after the occurrence.

Wind light, N.N.W. ; atmosphere hazy.

May 15, densely clouded.

May 16, densely clouded, and, at the time of occultation of 86 Virginis, raining.

COMPARISON OF CHRONOMETERS.

April 22, 1856, after occultations of α Scorpii,

		h.	m.	s.	
Sid. 7.	231 =	15	20	58.5	
Mean 7.	1911 =	2	20	52.0	coincidence.

May 13, 1856, after observations,

		h.	m.	s.	
	231 =	13	04	06.0	
	1911 =	22	42	35.0	coincidence.
14, 1856,	231 =	11	32	14.5	
	1911 =	21	07	05.0	coincidence.

14, 1856, after occultation of Mars.

	h.	m.	s.	
231 =	17	09	06.0	
1911 =	2	43	02.0	coincidence.

APPENDIX No. 27.

Method of observing azimuth, employed at Cat Island, by J. E. Hilgard, assistant U. S. Coast Survey.

A mark was placed nearly in the vertical of Polaris, at elongation, the aim being so to place it that the star would be equally on both sides of it during the term of observation, as originally designed at Spencer's Hill by the Superintendent.

The difference between star and mark was measured micrometrically, but instead of using a telescope-micrometer with moveable wire, the azimuth-micrometer of a 26-inch transit instrument was used, the fixed wire being pointed alternately at star and mark. The collimation error is eliminated by reversal.

The longer transit-axis and delicate level made the use of a transit instrument preferable to that of the Gambey theodolite used in the measurement of horizontal angles ; and the facility with which the observations can be made recommends the method for more frequent employment, in cases when a mark can be obtained in a proper position.

Great care is necessary in centreing the theodolite, used for referring the mark to one of the lines of the triangulation, in the line of collimation of the transit when pointed at the mark, especially when the latter is not far distant. It may be simply and accurately effected in the following manner: insert a pencil nearly into the centre of a cork, and fit the latter into the eye-piece of the transit telescope, removing the eye-lens. With the point of the pencil describe a mark on the stand, under the vertical position of the telescope, by estimation, using the motion of the diaphragm tube to get the proper length. Repeat the same with the telescope reversed in the bearings, and the middle between the two lines described will be accurately in the vertical in which the theodolite is to be mounted.

The following is a specimen of the work:

Western elongation of Polaris, December 5, 1855:

Time of elongation by chronometer = 7*h.* 06*m.* 00*s.*

Value of 1 divis. of micrometer = 2″.18 = value of 1 div. of level = 2″.0.

Increase of micrometer readings corresponds to movement of telescope from north to west.

Object.	Lamp.	Level.			Time.			Micrometer.		Time fr. elong.		Reduction.	Remarks.
					h.	*m.*	*s.*	*t*	*d*	*m.*	*s.*	″	
Mark	E.				7	15		1	86.0				
									86.1				
									85.8				
Polaris		D.	30.5	30.5	7	18	59.5		77.8	12	59.5	— 9.7	
		R.	30.5	30.5		19	21.5		77.2	13	21.5	10.2	
						19	47.0		77.2	13	47.0	11.0	
	W.					21	55.5		75.3	15	55.5	14.5	
						22	16.5		75.9	16	16.5	15.3	
						22	45.5		75.0	16	45.5	16.2	
												—12.82	
		R.	30.0	31.0									
Mark		D.	31.5	29.5	7	23			87.0				
									86.0				
			122.5	121.5					87.0				
			— 1.										
			= — ″.15										

Mark, lamp E.	86.0				
		Mean,	86.35		
Mark, " W.	86.7				
Star, " E.	77.4				
		Mean,	76.40		
Star, " W.	75.4				″
Mark W. of Star			+9.95	=	+ 21.69
Reduction to elongation					— 12.82
Level correction					— 0.15
Mark W. of elongation					+ 8″.7

Six sets were observed in about one hour, with a probable error of ± 0″.6 for a single set, as in the above example.

APPENDIX No. 28.

On the general distribution of terrestrial magnetism in the United States, from observations made in the U. S. Coast Survey and others: by A. D. Bache, Superintendent, and J. E. Hilgard, Assistant U. S. Coast Survey.—(*Sketches Nos.* 61 *and* 62.)

During the progress of the Coast Survey within the last twelve years, observations of the magnetic elements have been made, under special instructions from the Superintendent, at most of the astronomical stations, and near many capes and harbors where a knowledge of the variation of the compass was requisite for the use of navigation. The number of magnetic stations now amounts to about one hundred and sixty, distributed (irregularly as yet) along the entire seacoast of the United States, on a great portion of which magnetic observations were now made for the first time. The object of this paper is to deduce from the Coast Survey observations, in connection with others of recent date, the general distribution of terrestrial magnetism in the United States, as far as the data available will warrant the conclusions.

These observations have been discussed from time to time under the immediate direction of the Superintendent of the Coast Survey, with the double purpose of determining the distribution of magnetism in different parts of the United States and the local irregularities. Observations have also been repeated at many places where the discrepancies indicated the necessity for such a course, and generally resulted in throwing the discrepancy upon the existence of local attraction.

The area under discussion is so large, and the observations comparatively so sparse, that nothing more than the *general* distribution can at present be attempted. Local deviations from the general system, of greater or less magnitude and extent, are apparent in the table of residuals given at the close of this paper; which must be ascribed mainly to local attraction, since the errors of observation are far less in amount, and point out localities where additional observations will be most useful.

The results of the Coast Survey observations are given in Table I, which gives the latitude and longitude of the stations, the declination, dip, and horizontal intensity of the earth's magnetic force, the date of the observations, and a reference to the particular locality, its geology, and other circumstances.

The record of these observations and the details of methods and instrumental constants will shortly be published as part of the Coast Survey records and results, for the publication of which Congress has provided. A brief notice will therefore suffice here.

In observing the *declination*, the magnetic meridian has generally been obtained by means of collimator magnets, using Gauss and Weber's transportable magnetometer; while the astronomical meridian was derived from the triangle sides of the Coast Survey, or obtained by direct observations.

The *dip* has been observed with needles of from six to ten inches in length, made by Gambey and by Barrow. Two needles have generally been used; or when one only was employed it has been carefully tested and compared.

The *horizontal intensity* has been determined in absolute measure by vibrations and deflections, according to the methods of Gauss and Lamont. The units of measure are those used in the British surveys.

From the agreement of repeated observations, it is inferred that the uncertainty of the observations at a particular spot does not exceed one or two minutes of arc in the declination and dip, and $\frac{1}{500}$ part of the horizontal force.

The data derived from other sources that are combined with the Coast Survey observations are all of recent date, in order not to introduce much uncertainty into the reduction to a common period. They are:

1. Observations by Lieutenant (now Colonel) LEFROY, of the Royal Artillery in Canada, along the St. Lawrence, and at Toronto; being part of those published by Colonel SABINE, in the *Philosophical Transactions*, 1846 and 1849.

2. Observations made in connection with the survey of the northeastern boundary; *ibid.*

3. Observations of horizontal intensity in Waterville, Maine, by Professor G. W. KEELEY, in 1847; *Phil. Trans.* 1848.

4. Observations by the late Dr. JOHN LOCKE in various parts of the United States, especially in Ohio and the northwestern States. (*Am. Phil. Trans.* 1846, and *Smithsonian Contrib.* 1852.) The values of horizontal intensity in this series are originally expressed in terms of the force at Cincinnati, and have been converted into British units through the observations at Toronto, which is one of the stations.

5. Observations in various parts of the middle and western States, by Professor E. LOOMIS. *Am. Phil. Trans.*, vols. VII and VIII.

6. Observations made on the Mexican boundary surveys, under the direction of Major W. H. EMORY, U. S. A., recently presented by him to the *American Academy of Sciences.*

7. Observations made by Captain WHIPPLE'S party in the Pacific railroad explorations, near the 35° parallel of latitude. This series, not heretofore published, was kindly furnished by Captain A. W. WHIPPLE, U. S. Topographical Engineers, and is given in full in Table II. It will be seen that a large number of the stations are at a great elevation above the sea level. The effect of elevation on the action of the earth's magnetism has generally been found insensible, and in the absence of any known correction the observations have necessarily been used without regard to height. The observations have been made with a Fox dip-circle—Cambridge, Massachusetts, being used as a reference station for the intensity. The numbers in the table denoting the total intensity may be considered as referring to the arbitrary scale in which the total force at London is 1.372, with the usual uncertainty on account of secular variation.

For use on the map they have been multiplied by 7.41 to give the total intensity in British units, and by the cosine of the dip for the horizontal force. The factor 7.41 is the ratio of 13.32; the total intensity in British units at Cambridge, Massachusetts, from observations by Professor Bond, and the Coast Survey observations in the vicinity, to 1.798, the reference number in the table.

8. Table III gives some observations of declination not before published, collected from various sources for this discussion.

Corrections for secular variation.—The observations in the discussion have been reduced to the common date of January, 1850, by the best values for the annual change that could be arrived at.

The annual change for the declination and dip has been used, as found in the discussions by Mr. C. A. SCHOTT, printed in the present volume.

For the northwestern States we deduce from scanty data, and have applied an annual change of from 1′.6 to 2′ decrease of easterly declination.

Determinations of intensity in absolute measure are of so recent a date that but little is known of its secular variation. Observations of the horizontal force at Toronto, Boston, New York, Philadelphia, and Pascagoula, made during the interval between 1843 and 1855, concur in showing an annual decrease of nearly $\frac{1}{1000}$ part of the force. If we suppose the total force to remain constant, the known increase of the dip would account for a rather larger diminution of the horizontal component; and since it is probable that the total intensity is likewise slightly on the increase, the result obtained from our scanty data may be considered sufficiently well established to be used.

Our knowledge of the secular changes on the Western Coast and in the Territories is so deficient that no satisfactory reduction can be applied to the observations. The changes, however, are known to be small, and the observations do not differ greatly in date. Their mean date is about 1852, which may be considered as the period to which the western part of our map corresponds more nearly than to 1850.

Construction of Maps.—In the construction of the lines on the map (Sketches Nos. 61 and 62) both the graphic and analytical methods have been used.

Observations within limited spaces were united into groups, by taking the arithmetical means; a number of such groups were combined by conditional equations of the second degree, amounting to an interpolation by second differences.

The several systems of groups were so arranged as to overlap, and the slight disagreement in the joining was adjusted by an interpolation, partly graphic and partly arithmetical.

When the latitudes and longitudes of stations have appeared unsuitable co-ordinates of position, owing to the stations being distributed in an oblique direction to the meridian, they were carefully projected on a map, and referred by measurement to an assumed axis of co-ordinates in any convenient linear measure; the lines deduced from the conditional equations so formed, being projected according to the same system, the latitudes and longitudes of points in them could be read off and tabulated, the artificial system serving only as a convenient means of interpolation.

On the accompanying maps the lines of equal declination, dip, and horizontal intensity have been drawn only as far as they were warranted by observations. For places within the range of the lines approximate values may readily be obtained by graphical interpolation.

Table IV gives the differences between the observed values at the Coast Survey stations, reduced to 1850, and the corresponding values on the maps. It will be seen that there are a few large residuals, sometimes exceeding 2° in declination, 1° in dip, and $\frac{1}{20}$ of the horizontal force, which belong to isolated stations, (see Mt. Pleasant, No. 5, and Patuccawa, No. 15,) or very limited localites, (see stations near Cape Ann, Nos. 20 to 24); in these cases local attraction is too apparent to allow the observations to be used in the construction of the map.

We find, further, that in certain more extended localities the residuals in declination, amounting in the average to about 20′ or 25′, have one sign, indicating a more general deviation from a regular system. Thus, the observed declinations near New York, eastward to Black Rock, and westward to Princeton, are larger than those deduced, while near Cape May, in the lower part of New Jersey and Delaware, they are less; in the western part of Massachusetts they are greater, in the eastern part they are less. For the want of more ample material, especially of observations in the interior, no attempt has at present been made to represent these irregularities in the system of lines. They are greatest in amount in the eastern and middle States, where the average of the residuals, irrespective of sign, is 16′, excluding the class first noticed. Along the shores of the Gulf of Mexico it is 6′; and on the western coast of the United States it amounts to 10′.

The residuals of the *dip* observations are less than those of the declination, amounting in the average to 9′, and there are a less number of large disturbances. When we consider that the disturbing polarities probably act nearly in the plane of the horizon, we may conclude that the irregularities of the dip should bear a still smaller proportion to those of the declination; and we see that the constant instrumental errors, which are larger for the dip than for the declination, are not without sensible effect on the magnitude of the residuals.

Upon the same consideration it will not be surprising that the residuals of the horizontal force observations are larger in proportion than those of the dip, being, in the mean, about the sixtieth part of the actual values of the horizontal intensities. A variation of 10′ in the dip would correspond to one of the one hundred and twentieth part of the horizontal force.

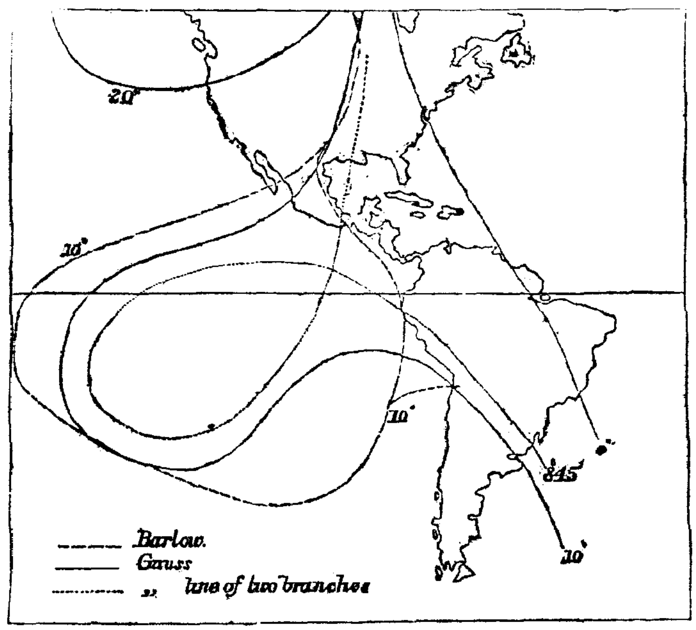
Comparison of Maps.—A comparison of the maps herewith presented, with other similar ones that have heretofore been constructed, cannot fail to be interesting and instructive.

Declination.—Allowing for the change in ten years, the lines on Prof. LOOMIS' map for 1840, (*Sill. Journ.* vol. XL,) agree well with the present map; considering the comparatively small number and often unreliable character of observations they were based upon, the agreement is remarkable, and leads to the hope that valuable results may be derived from the recent observations made in connection with surveys of public lands in the country west of the Mississippi, in which Burt's solar compass has been used to a great extent.

Colonel SABINE'S chart of the declination in the Atlantic ocean, (*Phil. Trans.* 1849,) covers only the northeastern portion of our map, which in that portion is based in part upon the same observations used by him. The agreement is not so close as it would be, if, in reducing the observations of 1844 and '45 to 1840, the epoch of the map, the secular change used had not been considerably in error, as already noticed in Mr. Schott's paper on the secular change of the declination, (*C. S. Report* for 1855.) As it is, the lines agree well in direction, but occupy too nearly the same position for the differences of epoch.

The most important comparison is that with Gauss' maps of the computed values of the declination, dip, and horizontal intensity. They are the only ones in which the three elements have been considered as having a necessary connection with each other, and while they may be considerably in error as to absolute quantities, the agreement in *form* with the lines on our maps, derived purely from observation, is strong evidence of the general correctness of the assumptions upon which they are based.

The data for the declination were taken by GAUSS from BARLOW'S map in the *Phil. Trans.*, 1833, of which the mean epoch cannot be later than 1830. The system of lines derived by Gauss on theoretical considerations differs in certain localities materially from that of Barlow. The annexed diagram exhibits the essential difference in form. While Barlow's line of 10° has several branches which diverge tangentially, according to Gauss such a divergence cannot take place; but when there is a space within which the declination is less than outside any portion of its limiting line, that line must form a loop, the two branches intersecting nearly at right angles, as shown in the looped line of 8° 45′. It must be remembered that the region in question is one where very few observations had been made in 1830, and that Barlow's system is probably quite as much as that of Gauss a theoretical interpolation, though graphically performed; and that hitherto there have been no observed facts, in the region of Texas and New Mexico at least, upon which a decision could be based.



A form of branching similar to that on Barlow's map, and at variance with Gauss' theory, occurs in *Hausteen's Erdmagnetismus*, and has been preserved on a recent map of the declination in his *Magnetiske Inclinations Forandring*, 1855.

It will be seen that if Barlow's system represents the forms correctly, the line of 9° easterly declination along the coast of Texas should turn to the *southeast;* while the line on our map, fixed by numerous observations, decidedly turns to the *southwest*, in conformity with Gauss' system. In going westward along the Mexican boundary, there is not a decrease and subsequent increase, as Barlow's map indicates, but a steady increase, established by the observations along that boundary. The general agreement in form between the lines on our map and the Gauss system is striking. Observations in Central America would at present be of the greatest value in deciding the matter under discussion. The isolated observation at Panama, Table III, has assisted greatly in fixing the direction of the line of 7° east, determining that it still turns to the southeast.

On the Atlantic coast the Gauss lines of declination agree well in position with ours, allowing for the difference of epoch. On the Western Coast, they are farther to the south, which seems contrary to what is supposed to be the secular change.

Dip.—With Loomis' map, before quoted, and Sabine's map of the dip in British America, (*Phil. Trans.*, 1846,) the agreement is excellent. The Gauss lines agree well in form, but differ from 2° to 2½° in the amount of dip. This is due to the errors of Horner's map, from which they are derived, and on which the lines are about 2½° out of position. It must be remembered that they were altogether interpolated, no observations of dip in the United States being known when Horner's map was constructed.

Horizontal intensity.—For a comparison of this element we have only Gauss' chart, on which the lines are affected by the errors of the dip lines, by means of which they have been derived from Sabine's general map of the total intensity for 1836. The values of the Gauss lines being expressed in the arbitrary scale, multiplied by 1,000, we reduce them to absolute measure through the observations at Toronto, where, in 1844, the total intensity in the arbitrary scale was 1.836, the dip 75° 13′.4, and the horizontal force 3.54, in absolute measure in British units, giving a multiplier of 7.56 for the arbitrary scale, or 0.00756 for Gauss' values. We find thus 3.78 equivalent to Gauss' line of 500, along which the actual horizontal force is 4.24 to 4.30; in the same place the dip is really 71° 30′, and on Gauss' map, 73° 15′. Corresponding differences exist in other parts of the map.

Supplementary Note.—The following results of observations recently made in Mexico for the Smithsonian Institution are added here, with the permission of the Secretary, from his eleventh report to the Regents.

The observations were made under the direction of Baron Mueller, of Marseilles, by Mr. A. Sontag, with the modern improved instruments.

No.	Name of station.	Latitude.	Longitude.	Declination east.	Dip.	Horizontal intensity.	Mag. mom't.	Date 1856.
		° ′	° ′	° ′	° ′			
1	Vera Cruz	19 12	96 09	8 17	43 58	7.533	0.4951	August 7–8
2	Potrero	18 56	96 48	8 39	42 51	7.576	0.4946	August 16–17
3	Orizaba	18 53	97 04	8 28	42 51	7.579	----------	August 26–27
4	St. Andrés Chalc.	18 59	97 14	8 13	42 38	7.594	----------	September 17–18
5	Mirador	19 13	96 37	8 02	43 48	7.528	0.4916	October 9–11
6	City of Mexico	19 26	99 05	8 46	41 26	7.581	0.4896	December 10–17

1. At the villa La Guaca, two hundred yards south of the city.
2. In the State of Vera Cruz.
3. In the State of Vera Cruz.
4. St Andrés Chalchecomula, State of Puebla.
5. In the State of Vera Cruz.
6. On the arched roof of the church of the convent of St. Augustine, at the same place where Humboldt made his observations.

TABLE I.

No.	Name of station.	Latitude.	Longitude.	Declination west.	Dip.	Horizontal intensity.	Date.	Locality, geology, and remarks.
		° ′	° ′	° ′	° ′			
1	Mount Harris	44 39.9	69 08.5	14 34.6	76 14.1	3.236	1855, Sept. 3–6	Near the geodetic station on the Dixmont hills, Penobscot county, Maine. Talcose slate of a grey color, running E.N.E and W.S.W., with a dip to the N.N.W. from 80° to 90°.
2	Ragged Mountain	44 12.7	69 08.7	14 16.8	75 41.2	3.339	1854, Sept. 27–30	Waldo county, Maine. Gneiss, impregnated with oxide of iron. Near the geodetic station on the summit.
3	Camden Village	44 12.0	69 05.0	13 57.1	75 41.5	3.340	1854, Oct. 26, Nov. 1.	On Penobscot bay, Waldo county, Maine. Gneiss. On ground of Mr. Hugier.
4	Mount Sebattis	44 09.1	70 04.5	12 53.5	75 40.6	3.411	1853, July 25–27	At the foot of Mount Sebattis, town of Wales, Maine, in the meadow of Colonel H. Marr. On the top of the hill the declination was found to vary from 9° to 14° in a space of 50 yards. The hill is composed of granite, with quartz veins and detached masses of mica
5	Mount Pleasant	44 01.6	70 49.0	14 32.1	76 01.5	3.211	1851, Aug. 21–25	Town of Denmark, Maine. Granite.
6	Cape Small	43 46.7	69 50.4	12 05.5	75 01.8	3.387	1851, Oct. 16–20	Town of Phippsburg, Maine, on the property of M. R. Morrison, fifty yards south of geodetic station.
7	Mount Independence	43 45.5	70 18.9	11 46.4	75 23.8	3.360	1849, Oct. 6–9	Town of Falmouth, Maine, in a field of Mr. Jos. Hobbes, close to the old road. Drift, clay, and gravel.
8	Burlington	44 27.5	73 10.0	9 57.1	75 56.8	3.425	1855, August 28	At the flag-staff on Camp ground, city of Burlington, Vermont. Drift, clay, and sand, 60 or 80 feet deep, overlying limestone and sandstone.
9	Bowdoin Hill	43 38.8	70 16.2	11 41.1	75 14.1	3.450	1851, Aug. 18–20	In the grounds of J. B. Brown, city of Portland. Drift, sand, and gravel.
10	Richmond Island	43 32.6	70 14.1	12 18.1	75 08.0	3.463	1850, Sept. 14–16	In a field near the dwelling-house of Dr. Cummings. Talcose and mica slate, intersected by a large trap dyke.
11	Fletcher's Neck	43 26.8	70 20.2	11 17.5	75 18.3	3.440	1850, Sept. 10–12	Mouth of Saco river, extremity of south point. Metamorphic slates.
12	Kennebunk Port	43 21.4	70 27.8	11 23.6	75 14.1	3.448	1851, Aug. 25–27	150 yards N.N.W of Kennebunk Port observatory. Granite.
13	Mount Agamenticus	43 13.4	70 41.2	10 09.8	74 54.7	3.456	1847, Sept. 23, Oct. 2.	On the summit of Mt. Agamenticus, town of York, Me. Sienite.
14	Cape Neddick	43 11.6	70 36.1	11 09.0	74 57.9	3.516	1851, Aug. 29–31	Town of York, Maine, in the field of Mr. J. Wyer, on the north side of Cape Neddick river, to the south of and near the road leading to the seashore. Granite underlying the soil.
15	Patuccawa	43 07.2	71 11.5	10 42.8	76 49.5	3.020	1849, Aug. 15–19	On the summit of the hill, in the town of North Deerfield, New Hampshire. Mica slate.
16	Kittery Point	43 04.8	70 42.7	10 30.2	74 57.2	3.500	1850, Aug. 28, Sept. 12	In an enclosure to the east of R. F. Gerrish's cottages. Argillaceous slate.
17	Mount Unkonoonuc	42 59.0	71 35.0	9 04.1	75 08.7	3.469	1848, Oct. 6–8	The highest and most easterly summit of that name in Goffstown, 10 miles west of Manchester. Mica slate.
18	Isle of Shoals	42 59.2	70 36.5	10 03.5	74 44.1	3.481	1847, Aug. 12–19	On the south side of the harbor of Hog island, 100 yards from the water. The Isles of Shoals are composed of mica slate and gneiss, with beds of granite ore, and some of them are traversed by dykes of trap.
19	Plum Island	42 48.0	70 48.5	10 05.6	74 54.9	3.530	1850, Sept. 18–20	Near Thompson's hotel, on Plum island, near Newburyport, Massachusetts. Drift covered with sea sand.
20	Annis Squam	42 39.4	70 40.3	11 36.7	----------	----------	1849, Aug. 28	Sienite. The sienite of the coast of Massachusetts is frequently traversed by dykes of trap, porphyritic trap, &c.

TABLE I—Continued.

No.	Name of station.	Latitude.	Longitude.	Declination west.	Dip.	Horizontal intensity.	Date.	Locality, geology, and remarks.
		° ′	° ′	° ′	° ′			
21	Beacon Hill,	42 36.2	70 38.3	11 21.1	74 26.4	3.617	1849, Aug. 24–27	On the eastern point of Gloucester, Massachusetts. Sienite.
22	Baker's Island Light	42 32.2	70 46.8	12 17.0	74 18.6	3.674	1849, Sept. 1–4	100 yards from the light, in the direction of Half-way Rock. Sienite.
23	Fort Lee	42 31.9	70 52.1	10 14.5		3.487	1849, Aug. 20	Salem, Massachusetts. Sienite.
	"	" "	" "	10 49.7	75 36.9	3.489	1855, Aug. 25	Centre of old fort. Granite, partly covered by clay and sand.
24	Coddon's Hill	42 30.9	70 50.9	11 49.8			1849, Sept. 6–8	Marblehead, Massachusetts. Sienite.
25	Little Nahant	42 26.2	70 55.5	9 40.9	74 29.5	3.555	1849, Aug. 15–17	On the hill. Sienite.
26	Dorchester Heights	42 20.0	71 02.2	9 31.4	74 12.7	3.587	1846, Sept. 6–8	On South Boston Heights, between reservoir and Asylum for the Blind. Drift at least 90 feet deep. Clay and sand, mixed with pebbles.
	" "	" "	" "	10 13.7	74 29.5	3.544	1855, Aug. 24	
27	Nantasket	42 18.2	70 54.0	9 37.4	74 15.9	3.566	1847, Sept. 1–3	Drift and alluvium, resting on argillaceous slate.
28	Blue Hill	42 12.7	71 06.5	9 13.5	75 05.6	3.519	1845, Sept. 28, Oct. 5	Dedham, Massachusetts Sienite.
29	Beacon-pole Hill	41 59.7	71 26.7	9 27.0	74 21.9		1844, Oct. 31, Nov. 18	Near Cumberland Hill village, Rhode Island. Granite. Iron ore occurs in the neighborhood.
30	Manomet Hill	41 55.6	70 35.1	9 16.9	74 30.0	3.640	1845, Sept. 9–11	Near Plymouth, Massachusetts. Drift.
	" "	" "	" "		74 01.2		1846, Sept. —	
31	Copecut Hill	41 43.3	71 03.3	9 08.8	74 09.5		1844, Sept. 27, Oct. 17	In the town of Fall River, Massachusetts. Granite. Iron ore occurs in the neighborhood.
32	Spencer's Hill	41 40.7	71 29.3	9 05.9	75 07.1		1844, July 29, Aug. 31	Near East Greenwich, Rhode Island. Metamorphic slate of carboniferous age.
33	Shootflying Hill	41 41.1	70 20.5	9 37.4	74 23.3	3.657	1845, Aug. 15–22	Near Barnstable, Massachusetts. Drift.
	" "	" "	" "	9 40.3	73 56.5	3.663	1846, Aug. 28–30	
34	Hyannis	41 37.9	70 18.1	9 21.6	73 49.2	3.682	1846, Aug. 14–26	On a hill near Hyannis Point, about 60 feet high. Drift.
35	Fairhaven	41 37.4	70 53.7	8 54.2	74 40.0	3.592	1845, Oct. 17–19	Opposite New Bedford, Massachusetts, 22 yards east of fort. Gneiss.
36	Tarpaulin Cove	41 28.1	70 45.1	9 12.1	73 49.8	3.696	1846, Aug. 7–9	Nashua, Massachusetts, N.E. of the light, near S. shore of the cove. Drift.
37	Indian Hill	41 25.7	70 40.3	8 43.9	73 41.4	3.734	1845, July 13, Aug. 2	Martha's Vineyard. Tertiary strata.
	" "	" "	" "	8 49.4	73 29.1	3.728	1846, Aug. 12–13	
38	Sampson's Hill	41 22.7	70 28.7	8 48.7	73 24.5	3.753	1846, July 22–27	On Chappaquiddick island, opposite Edgartown, Martha's Vineyard. Drift.
39	Nantucket	41 17.5	70 05.7	9 14.0	73 44.4	3.653	1846, July 30–31	On the north beach, near the edge of the town, due N. of Mitchell's Observatory. Drift.
	"	41 17.5	70 05.7	9 58.6	74 00.6	3.626	1855, Aug. 22	Argillaceous sand, overlying a stratum of clay, resting on gneiss.
40	McSparran's Hill	41 29.7	71 27.1	8 48.5	73 47.6		1844, July 10–24	South Kingston, Rhode Island, in a field near the angle of the roads to Kingston and Wickford.
41	Point Judith Light	41 21.6	71 28.6	8 59.7	73 45.1	3.788	1847, Sept. 5–9	100 yards towards Beavertail light.
42	Providence, R. I.	41 50.0	71 23.6	9 31.5	74 15.9	3.590	1855, Aug. 20	In the rear of Brown University, 198 feet from the central building. Quartz and gneiss rocks and mica schist.
43	Watch Hill	41 18.8	71 50.9	7 33.4			1847, Sept. 17–19	Half a mile north of Watch Hill lights, near Stonington, Connecticut. Granitic gneiss.
44	Stonington	41 20.0	71 54.0	7 38.1	73 25.0		1845, Aug. 8–9	Connecticut. Reddish granitic gneiss.
45	Groton Point	41 18.0	72 00.0	7 29.5			1845, Aug. 14	Near New London, Connecticut. Whitish felspathic gneiss, with mica seams.

46	Saybrook	41 16.0	72 20.0	6 49.9	74 33.8		1845, Aug. 20	Connecticut. Granitic gneiss.
47	Greenport	41 06.0	72 21.0	7 14.4	72 57.9		1845, Aug. 19	In Southold, Long Island. Drift.
48	Sachem's head	41 17.0	72 43.0	6 15.2			1845, Aug. 23	Connecticut. Reddish granitic gneiss.
49	Fort Wooster	41 16.9	72 53.2	7 27.2	74 16.6	3.667	1847, Sept. 25, Oct. 2	Near New Haven, Connecticut. Trap.
	" "	" "	" "	7 25.5	74 12.6	3.609	1848, Aug. 21–29	
50	Oyster Point	41 17.0	72 55.4	6 31.9	73 32.9	3.761	1848, Aug. 30, Sept. 1	Near N. Haven, in the meridian of Yale College observatory. Trap.
	" "	41 16.9	72 55.5	7 02.7	73 44.5	3.690	1855, Aug. 17	On Howard avenue, 503 feet from high-water mark, on foot of the avenue. Argillaceous soil.
51	New Haven	41 18.0	72 54.3	6 37.9	73 31.9	3.768	1848, Aug. 10–14	Near Pavilion hotel. Sandstone, underlying drift.
52	Milford	41 16.0	73 01.0	6 38.3			1845, Sept. 19	Greenstone and chloritic slate.
53	Bridgeport	41 10.0	73 11.0	6 19.3	73 21.3		1845, Sept. 18	Connecticut. Gneiss and mica slate.
54	Black Rock	41 08.6	73 12.6	6 53.5			1845, Sept. 20	Connecticut. Gneiss and mica slate.
55	Norwalk	41 07.1	73 24.2	6 49.4	73 09.8		1844, Sept. 14	Connecticut. On Judge Isaacs' hill. Granite.
56	Stamford	41 03.5	73 32.0	6 36.0	73 02.3	3.885	1844, Sept. 12	Connecticut. In the rear of the Union hotel. Granite.
57	Saw-pits	40 59.5	73 39.4	5 58.0	72 53.4		1844, Sept. 11	Steamboat landing at Port Chester, Westchester county, New York. Gneiss.
58	Drowned Meadow	40 56.1	73 03.5	6 03.6			1845, Sept. 12	Near Drowned Meadow village, north shore of Long Island. Drift and alluvium.
59	Lloyd's harbor	40 55.6	73 24.8	6 11.6	72 50.6	3.857	1844, Sept. 15	Huntington, Long Island. Drift, with boulders.
60	Oyster bay	40 52.3	73 31.3	6 50.5	72 58.8	3.894	1844, Sept. 16	North shore of Long Island. Drift.
61	New Rochelle	40 52.5	73 47.0	5 29.5	72 44.0	3.845	1844, Sept. 10	About 100 yards south of the Neptune house, in New Rochelle, Westchester county, New York. Gneiss and hornblendic rocks.
62	Sands' Point	40 52.0	73 43.0	7 14.6			1845, Sept. 27	40 yards E. N. E. from Sands' Point light. Drift, covered with alluvium.
	" "	" "	" "	6 09.9			1847, Oct. 8–11	Near the light-house.
63	Legget	40 48.9	73 53.0	5 41.0	72 52.7	3.976	1847, Oct. 16–20	In a cove north of Riker's island, Long Island Sound. Gneiss, covered with alluvium.
64	Greenbush	42 37.5	73 44.0	7 54.7	75 11.1	3.587	1855, Aug. 31	Opposite Albany, N. Y., near Second street, east of the Hudson River railroad track. Clayey sand and dark blue marl.
65	Cold Spring	41 25.0	73 57.3	5 34.0	73 54.8	3.790	1855, Sept. 1	Near the Hudson river, on a bluff close to the village. Granite.
66	Bloomingdale asylum	40 48.8	73 57.4	5 09.7	72 39.0	4.009	1846, April 30	Manhattan island. Gneiss rock, underlying the soil.
67	Columbia College, N. Y.	40 42.7	74 00.1	6 13.1	72 37.8		1844, Aug. 24	City of N. York. Gneiss rock, underlying drift, loam and gravel.
	" " "	" "	" "	6 25.3			1845, Sept. 4	City of New York.
68	Governor's island	40 41.5	74 00.8	6 39.6	72 46.3	3.926	1855, Aug. 7	New York harbor, between Fort Columbus and Castle Williams, in range with Trinity Church steeple and Battery flag-staff. Quartzose sand, overlying mica schist and granite.
69	Bedloe's island	40 41.4	74 02.3	7 02.1	72 59.2	3.920	1855, Aug. 8	New York harbor, north side of island, to the northward of the flag-staff. Quartzose sand, overlying metamorphic rock.
70	Receiving reservoir	40 46.7	73 57.8	6 28.0	72 44.4	3.938	1855, Aug. 11	City of New York, inside the receiving reservoir, near corner of 79th street and 7th avenue. Gneiss.
71	Newark	40 44.8	74 07.0	5 35.1	72 52.2	3.964	1846, May 14	New Jersey. Alluvial soil, sand, and gravel, superimposed on secondary red sandstone in place.
72	Mount Prospect	40 40.3	73 57.7	5 54.7	72 27.6	4.053	1846, May 6	Near Brooklyn, L. I. Drift, with small boulders of granite and trap.
73	Cole	40 31.9	74 13.8	5 37.4	72 34.2	4.028	1846, May 7	In Westfield, southwestern part of Staten Island. Drift, with small boulders.
74	Sandy Hook	40 28.0	73 59.8	5 51.0	72 37.9	4.077	1844, Aug. 20–22	250 yards north of light. Greensand formation; alluvial sand.
	" "	40 27.6	73 59.9	6 11.2	72 52.0	3.917	1855, Aug. 14	About 250 feet west of the light-house, on the top of a dune. The Hook consists of downs, and the quartz sand was found 25 feet deep.
75	Mount Rose	40 22.2	74 42.9	5 31.8	72 42.5	4.130	1852, Aug. 13–15	About five miles west of Princeton, N. J., in a field near the house of Mr. Thomas Hunt. Trap rock protruding through secondary red sandstone.

28 c s

TABLE I—Continued.

No.	Name of station.	Latitude.	Longitude.	Declination west.	Dip.	Horizontal intensity.	Date.	Locality, geology, and remarks.
		° ′	° ′	° ′	° ′			
76	White Hill	40 08.3	74 43.6	4 25.9	72 06.2	4.147	1846, May 20	Near Bordentown, N. J., on the bank of the Delaware river. Cretaceous marl.
77	Vanuxem	40 06.7	74 52.7	4 27.8	72 22.3	4.068	1846, July 10-11	At Professor Vanuxem's, two miles above Bristol, on the Delaware river, 100 yards N.W. of the canal. Sand, clay, and gravel, superimposed on metamorphic rock.
78	Girard College	39 58.4	75 09.9	3 51.1	72 01.0	4.143	1846, May 23	In the yard of the magnetic observatory, at Girard College, Philadelphia.
	" "	" "	75 09.8	4 31.7	72 17.7	4.226	1855, Sept. 5	To the northward and eastward of the college, within the enclosure, and in the road in the rear of the smaller building next to the college. Metamorphic rock, below gravel, etc.
79	Yard	39 58.3	75 22.9	6 42.3	73 01.4	3.876	1854, Oct. 25-28	About 10 miles west of Philadelphia, and 250 yards E.S.E. of the trigonometrical station.
80	Chew	39 48.2	75 09.7	3 45.2	72 14.4	4.105	1846, July 15	Near Woodbury, N. J. Marl and greensand of the cretaceous formation.
81	Tucker's island	39 30.8	74 16.9	4 27.8			1846, Nov. 10	Entrance to Little Egg harbor, N. J., northwestern point of island. Alluvium and white sand.
82	Tuckerton	39 36.1	74 19.5		72 12.3	4.063	1846, Nov.	
83	Wilmington	39 44.9	75 33.6	2 30.7	71 25.4	4.236	1846, May 27	Delaware. A hill 1¼ mile W.N.W. of the town hall. Trap, covered with red clay. Local attraction.
84	Sawyer	39 42.6	75 33.8	2 48.3	71 57.5	4.175	1846, June 3	Three miles south of Wilmington, Del. At the edge of the tertiary formation, no rocks or boulders apparent.
	Church landing	39 40.6	75 30.4	5 49.1	71 22.0	4.311	1846, June 6	New Jersey, on the Delaware river. Drift. Local attraction ascertained to exist, by partial observations at three localities.
86	Fort Delaware	39 35.3	75 33.8	3 16.8	71 34.9	4.226	1846, June 14	Peapatch island, Delaware river. Alluvial mud at least 70 feet deep.
87	Hawkins	39 25.6	75 17.0	2 58.8	71 42.6	4.224	1846, June 20	Near Roadstown, N. J. Cretaceous formation. Some ferruginous sandstone in vicinity.
88	Pine Mount	39 25.0	75 19.9	3 14.2	71 41.4	4.237	1846, June 19	An isolated hill near Greenwich, N. J. Cretaceous; unmagnetic iron ore.
89	Bombay Hook light	39 21.8	75 30.3	3 18.5	71 39.5	4.201	1846, June 17	About 60 yards E.S.E. of the light-house. Alluvial clay and sand.
90	Port Norris	39 14.6	75 01.0	3 04.4	71 39.6	4.211	1846, June 23	New Jersey. Cretaceous marl and sand.
91	Egg Island light	39 10.5	75 08.0	3 03.0	71 45.1	4.206	1846, June 25	Delaware bay, 60 yards S. by W. of light-house. Cretaceous marl and sand.
92	Town Bank	38 58.6	74 57.4	2 59.0	71 23.6	4.269	1846, June 30	At Price's, near Cape May. Cretaceous marl and sand.
93	Cape May light, (old)	38 55.8	74 57.6	3 05.1	71 25.8	4.255	1846, June 28	70 yards S.E. of light-house. Cretaceous marl and sand.
	Do....do..(new)	38 55.8	74 57.4	3 45.4	71 34.4	4.182	1855, Aug. 3	About 160 yards west of the light-house, near the sand dunes. Quartz, sand, and broken shells.
94	Lewes' Landing	38 48.8	75 11.5	2 45.0			1846, July 1	Near Cape Henlopen.
95	Pilot Town	38 47.1	75 09.2	2 42.7	71 18.5	4.290	1846, July 2-3	On Cape Henlopen. Clay and sand.
96	Osborne's ruin	39 27.9	76 16.6	2 32.4	71 47.6	4.143	1845, June 19-24	Near Abingdon, Md. Talcose slate and hornblende.
	Susquehanna light	39 32.4	76 04.8	2 13.7	71 52.1	4.086	1847, July 6-7	A short distance to N.W. of light-house, at the mouth of the Susquehanna river. Ferruginous clay and sand.

98	Finlay	39 24.4	76 31.2	2 14.6	71 52.9	4.059	1845, June 13-14	On Cub hill, the property of L. B. Finlay, 9 miles north of Baltimore, on the Harford turnpike. Metamorphic rocks, underlying gravel and sand.
	"	" "	" "	2 18.5	71 45.2	4.170	1846, April 16	
99	Pool's island	39 17.1	76 15.5	2 29.3	71 52.1	4.117	1847, June 24-27	Chesapeake bay, near the dwelling of P. Wethered, on the upper island. Alluvial clay and sand.
100	Rosanne	39 17.5	76 42.8	2 10.9	72 06.6	4.053	1845, June 10	On Prospect hill, 5 miles from Baltimore, north of the old Frederick road. Alluvial clay and sand.
101	Fort McHenry	39 15.7	76 34.5	2 18.6			1847, April 29	Baltimore harbor; between the hospital and western stable. Ferruginous sand and clay.
102	North Point	39 11.7	76 26.3	1 36.7	71 29.5	4.183	1846, July 7-8	Between the two lights at the mouth of the Patapsco river. Ferruginous sand and clay.
"	" "	" "	" "	1 39.6			1847, April 27	
103	Bodkin light	39 08.0	76 25.2	2 01.9	71 43.1	4.189	1847, April 25-26	20 yards S.S.E. from light-house. Ferruginous sand and clay.
104	Kent island (1)	39 01.8	76 18.8	2 30.2	71 16.6	4.208	1849, June 27, July 4	North end of Kent island, Chesapeake bay. Ferruginous sand and clay.
105	South Base, Kent island	38 53.8	76 21.7	2 24.3	71 37.0	4.206	1845, June 3-4	On the west shore of Kent island, opposite Thomas' point, 21 yards north of monument. Ferruginous sand and clay.
106	Taylor	38 59.8	76 27.6	2 14.4	71 40.2	4.231	1845, May 31, June 1	On the north side of Severn river, opposite Annapolis, Maryland. Ferruginous sand and clay.
"	"	" "	" "	2 18.0	71 19.3	4.221	1847, May 28, June 3	
107	Marriott	38 52.4	76 36.2	2 09.4	71 10.9	4.260	1846, May 24, June 6	A prominent hill near West river, Md., the property of Bushrod Marriott. Greensand formation, ferruginous clay and marl.
"	"	" "	" "	2 05.0	71 13.0	4.228	1849, June 12-20	
108	Webb's hill	39 05.3	76 40.2	2 07.9	71 24.0	4.279	1850, Nov. 20-23	Anne Arundel county, Maryland, near the Annapolis railroad, 12 miles from Annapolis. Greensand formation, ferruginous clay and marl.
109	Soper's hill	39 05.1	76 56.7	2 07.1	71 56.5	4.142	1850, July 20-26	Prince George's county, Maryland, 14 miles from Washington City, on the old Columbia road; property of J. B. Downs. Talcose slate.
110	Hill's hill	38 53.9	76 52.5	2 18.6	71 12.2	4.316	1850, Sept. 19-22	Prince George's county, Maryland, 6 miles east of Washington City. Ferruginous clay and sand.
111	Causten's hill	38 55.5	77 04.1	1 11.3	71 18.9	4.229	1851, June 14-19	Near Georgetown, D. C., 122 yards west of the geodetic station, in the grounds of J. H. Causten. Mica slate with quartz veins, underlying ferruginous clay and gravel.
"	" "	38 55.5	77 04.1	1 06.2	71 30.2	4.250	1855, Sept. 8, Oct. 9	At the geodetic station. 1° 10′.3 in September, and 1° 02′.0 in October, by two different instruments.
"	" "	38 55.5	77 04.1	1 06.0			1855, October 9	Same station as in June, 1851.
112	Washington city, D. C.	38 53.2	77 01.2	5 44.2	71 27.0	4.337	1855, July 31	Near Magnetic Observatory in the Smithsonian Grounds. Affected by local attraction, changing within the enclosure as much as 1½°. Declination on Capitol Hill, near Gilliss' station, by compass needle, 2° 25′. Ferruginous clay and sand overlying mica schist.
113	Davis	38 20.4	75 06.0	2 33.0	70 57.7	4.332	1853, Sept. 25-27	On the west shore of Sinepuxent bay, east of Berlin, Maryland. Ferruginous clay and sand.
114	Roslyn	37 14.4	77 23.6	0 26.5	69 17.3	4.614	1852, Aug. 9-13	Near Petersburg, Virginia. Drift, ferruginous clay.
115	Stevenson's Point	36 06.3	76 10.7	1 39.6	68 54.5	4.660	1847, Jan. 30, Feb. 15	Western point at the mouth of Little river, Albemarle Sound, N. C. Tertiary clay and sand.
116	Shellbank	36 03.3	75 43.8	1 44.8	68 37.8	4.714	1847, Mar. 27, Apr. 8	On Albemarle Sound, east point of entrance into Currituck Sound. Alluvial mud, sand, and shells.
117	Bodies island	35 47.5	75 31.6	1 13.4	68 18.1	4.755	1846, Dec. 26-28	North Carolina, near the beach, about 5 miles N.N.W. of light-house. White sand.
118	Raleigh, N. C.	35 46.8	78 37.8	East. 0 44.5	68 11.6	4.943	1854, January 7-11	Station 105 feet east and 26 feet north of centre of Capitol dome. Granitic rock underlying the soil.
119	De Rosset	34 14.0	77 56.5	1 13.5	66 47.2	5.174	1854, May 30, June 2	On a lot adjoining Dr. Drane's residence, north side of Market street, Wilmington, N. C. Tertiary clay, gravel, and sand.
120	Columbia, S. C.	34 00.0	81 02.0	3 01.7	66 07.7	5.274	1854, February 19-23	In the Capitol square, near the southwestern corner.

TABLE I—Continued.

No.	Name of station.	Latitude.	Longitude.	Declination east.	Dip.	Horizontal intensity.	Date.	Locality, geology, and remarks.
		° '	° '	° '	° '			
121	Allston	33 21.7	79 12.3	2 06.5	65 29.5	5.402	1853, December 21-27	Near Georgetown, S. C. Alluvium.
122	Macon, Ga	32 50.4	83 37.6	4 36.5	63 51.0	5.637	1855, January 10-16	85 yards southwest of Bibb county Male Academy. Clay.
123	Breach inlet	32 46.3	79 48.7	2 16.5	64 31.9	5.457	1849, April 1-22	On Sullivan's island, Charleston entrance, S. C. White sand.
124	East base, Edisto island	32 33.3	80 10.0	2 53.6	64 04.1	5.532	1850, April 2-7	Edisto island, S. C. Tertiary formation, alluvial mud, clay, and sand.
125	Savannah	32 05.0	81 05.2	3 40.3	63 40.0	5.600	1852, April 26-28	On Hutchinson's island, in range of Exchange and Presbyterian Church steeples, near the second embankment from the river. Alluvium.
126	Tybee island	32 01.5	80 50.6	3 32.1	63 38.4	5.584	1852, April 30, May 2.	Near the mouth of Savannah river, on a sand dune near the boat-house.
127	Cape Florida	25 40.4	80 09.8	4 25.2	56 13.0	6.615	1850, February 22-25	On the inside beach of Key Biscayne, the light-house bearing southwest. Black mud and white sand.
128	Sand key	24 27.2	81 52.7	5 28.8	54 25.3	6.758	1849, August 19-21	Near Key West, Florida. A small island on Florida reef, composed of detritus of marine shells and coral.
129	Depot key	29 07.5	83 02.8	5 20.5	59 55.3	6.140	1852, March 14-16	Cedar Keys, Florida, on the highest point of the island. Drifted white sand on alluvial mud.
130	St. Mark's light	30 04.5	84 12.5	5 29.2	----------	----------	1852, April 2	In the salt marsh, about 400 yards north of the light.
131	Dog island	29 47.1	84 36.0	5 51.2	----------	----------	1853, April 1	Apalachicola entrance, (eastern.) White sea sand.
132	St. George's island	29 37.4	85 01.1	6 02.1	----------	----------	1853, April 6	Near Cape St. George, west entrance to Apalachicola bay, Fla. White sea-sand.
133	Cape St. Blas	29 39.6	85 23.9	6 06.5	----------	----------	1854, January 31	Florida. White sea-sand.
134	Hurricane island	30 04.4	85 40.3	6 12.2	----------	----------	1854, February 5	St. Andrew's bay, Florida. White sea-sand.
135	Fort Morgan	30 13.9	88 00.3	7 04.1	----------	6.218	1847, May 21-30	400 yards northeast of the northwest bastion of Fort Morgan, Mobile Point, Alabama. Drifted white sand.
136	East Pascagoula	30 20.7	88 31.8	7 12.6	60 27.2	6.220	1847, June 18-20	Mississippi. About a mile east of the mouth of Pascagoula river, in the village near the shore. Tertiary formation, ferruginous clay and white sand. Dip observed in 1848.
	" "	" "	" "	7 08.9	----------	6.174	1855, January 23-25	
137	Montgomery, Ala	32 22.0	86 18.0	5 18.3	63 05.4	5.850	1855, April 2-8	Near northeast corner of Capitol square. Deep red clay.
138	Fort Livingston	29 16.7	89 48.5	7 38.4	----------	----------	1853, January 9	Barataria bay, La. Alluvium, covered with drifted white sand.
139	Belle Isle	----------	----------	----------	----------	----------	----------	----------
140	Isle Dernière	29 02.0	90 54.3	8 19.2	----------	----------	1853, February 20	Caillou bay, La. Alluvium, covered with drifted white sand.
141	Dollar Point	29 26.0	94 52.6	8 57.4	57 53.3	6.541	1848, April 24-28	On Galveston bay, 10 miles northwest of Galveston, Texas. Sandy loam.
142	East base	29 12.9	94 55.4	9 05.0	57 42.1	6.491	1853, March 16-21	On Galveston island, 10 miles southwest of Galveston, and half a mile from the Gulf shore. Sandy loam.
143	Jupiter	28 54.8	95 20.1	9 08.7	57 11.7	6.582	1853, May 10-15	Four miles southwest of Quintana, Texas, near the beach. Drifted sand.
144	Rio Grande	25 57.4	97 07.6	9 00.9	52 23.6	----------	1853, November	Near the mouth, on the American side. Alluvium.
145	San Diego	32 42.0	117 13.3	12 28.8	----------	----------	1851, April 28, May 7.	California. At the Plaza near the "quarters." Very coarse sandstone. The high ridge of Point Loma is to the west.
	" "	" "	" "	12 31.7	57 38.6	6.271	1853, October 15	At the Plaza, near the custom-house.
146	San Pedro	33 46.0	118 16.0	13 30.5	59 32.6	6.144	1853, Nov. 24-26	On the open plain, about 3 miles north of San Pedro. Gravel, resting on beds of recent fossil shells.

147	Point Conception	34 26.9	120 25.6	13 50.2			1850, September 5-8.	Near the mouth of the valley of El Coxo. A rich soil. Surrounding hills show limestone, quartz, &c.
148	San Louis Obispo	35 10.6	120 43.5	14 16.9	59 42.2	6.002	1854, Jan. 30, Feb. 7.	The surrounding hills are of soft limestone, resting on coarse red sandstone, bearing enormous fossil remains, probably of tertiary age.
149	Point Pinos	36 38.0	121 54.4	14 58.3			1851, Feb. 6-10	Near Monterey, California. A rich soil, resting on sandstone. Beach formed of large granite boulders.
150	San Francisco	37 47.6	122 26.8	15 26.9			1852, February 18-28	Near the Presidio. Surrounding hills, limestone.
151	Bucksport	40 46.6	124 10.7	17 06.5			1853, July 19-20	On the beach. Sand and marsh.
152	Humboldt	40 44.7	124 11.0	17 04.5			1854, Apr. 25, May 2.	At the foot of the western part of the bluff, composed of ferruginous clay and sand, resting on gravel, bearing fossil remains of *elephas primigenius*.
153	Ewing harbor	42 44.4	124 28.8	18 29.7			1851, Nov. 19-29	Near Cape Orford, Oregon. Geology very varied. South of Port Orford, coal and plumbago. North, limestone, filled with fossil shells.
154	Cape Disappointment	46 16.6	124 02.0	20 19.1			1851, July 5-9	On the beach; white sand, mixed with black ferruginous and auriferous sand. Surrounding hills, basalt.
155	" "	" "	" "	20 45.3			1851, July 14-19	On the summit of the Cape. Horizontal columnar basalt.
156	Scarboro' harbor	48 21.8	124 37.2	21 29.9			1852, August 17-23.	Near Cape Flattery, Washington Territory. Sand. Surrounding hills varied, limestone principally; basalt cropping out at Tatoosh island.
157	Waddah island, Neéah Bay.	48 22.0	124 36.6	21 46.9	71 07.0	4.276	1855, August 13-16.	On shore, opposite the island, near Cape Flattery, Washington Territory. Sandstone and shales of coal measures.

TABLE II.

Magnetic observations made on the Pacific Railroad explorations, near parallel 35°, by Lieut. J. C. Ives, under the directions of Capt. A. W. Whipple, U. S. Top. Engineers.

No. of ref.	Date.	Name of place.	Latitude.	Longitude.	Elevation.	Magnetic inclination.	Magnetic declination.	Total magnetic inten.
			° ′	° ′		° ′	° ′	
1	Aug. 9, 1850	Cambridge Observatory	42 23	71 07	--------	74 34	9 30	1.798
1	May 10, 1854	" "	42 23	71 07	--------	74 33	9 46	1.798
2	Oct. 17, 1853	Albuquerque	35 06	106 38	5026	62 28	13 25	1.689
3	Nov. 9, "	Isleta	34 54	106 40	4910	62 24	13 13	1.686
4	12, "	Rio San José	35 01	107 14	5556	63 18	13 46	1.689
5	14, "	Covéro	35 05	107 26	5880	62 26	13 49	1.689
6	15, "	Hay camp°	35 05	107 39	6081	35 39	35 56	1.566
7	17, "	Agua Fria	35 02	107 58	7757	62 05	13 25	1.687
8	18, "	Prescription rock†	35 03	108 14	7238	62 03	12 57	1.679
9	22, "	Zuni river	35 06	108 39	6336	62 02	13 24	1.683
10	26, "	Arch spring	35 05	108 48	6350	61 55	--------	1.682
11	28, "	Cedar Forrest	35 01	108 55	6162	61 40	13 01	1.679
12	29, "	Jacob's well	35 04	109 14	3973	61 59	13 44	1.674
13	30, "	Navajo spring	35 06	109 20	5665	61 58	13 23	1.675
14	Dec. 1, "	Carriso creek	35 06	109 32	5550	62 05	13 54	1.673
15	2, "	Near Lithodendron creek	35 02	109 41	5500	61 57	13 33	1.667
16	3, "	Near Rio Puerco of the west	34 58	109 52	5110	61 46	14 00	1.668
17	5, "	Colorado Chiquito, or Flax river	34 53	110 04	5015	62 15	13 42	1.670
18	7, "	On Colorado Chiquito	35 00	110 25	4735	61 54	13 40	1.665
19	8, "	"	35 01	110 30	4760	61 41	13 21	1.663
20	15, "	"	35 05	110 33	4675	61 44	--------	1.662
21	16, "	"	35 12	110 37	4618	61 45	13 39	1.668
22	17, "	"	35 18	110 53	4594	61 55	13 42	1.667
23	18, "	"	35 21	110 56	4570	62 03	--------	1.678
24	29, "	Saroux spring	35 17	111 39	7378	61 33	13 52	1.659
25	Jan. 9, 1854	Cedar creek	35 21	112 20	5672	62 06	13 49	1.674
26	21, "	Pueblo creek	34 56	112 46	5203	61 13	13 59	1.652
27	23, "	Williams' river‡	34 59	112 57	5752	61 06	14 48	1.648
28	28, "	"	35 07	113 13	4680	61 17	13 40	1.618
29	30, "	Head of White Cliff creek	35 12	113 21	4784	61 14	--------	1.659
30	Feb. 1, "	White Cliff creek	35 08	113 31	3526	60 48	14 42	1.648
31	4, "	Big Horse spring	35 01	113 36	2784	61 02	14 18	1.631
32	8, "	Williams' river	34 36	113 28	1657	60 36	14 02	1.622
33	9, "	"	34 32	113 28	1450	60 44	13 58	1.627
34	13, "	"	34 17	113 26	1015	60 14	13 24	1.631
35	15, "	"	34 13	113 33	899	60 08	13 41	1.629
36	16, "	Camp 123	34 14	113 39	868	60 10	--------	1.624
37	20, "	Camp 126	34 17	113 56	441	60 11	--------	1.623
38	21, "	On Colorado river	34 23	114 06	382	60 34	14 08	1.626
39	22, "	Camp 129	34 27	114 11	416	60 35	--------	1.628
40	23, "	Camp 130	34 36	114 16	590	60 30	13 51	1.627
41	25, "	Camp 132	34 46	114 23	432	60 48	13 36	1.629
42	Mar. 1, "	Camp 135	34 52	114 32	430	60 57	13 56	1.635
43	3, "	Pai-ute creek	35 06	114 54	2790	61 10	14 17	1.635
44	6, "	Near Marl springs	35 11	115 33	3793	60 56	13 59	1.627
45	7, "	Sand camp	35 06	115 46	2038	60 49	--------	1.632
46	8, "	Soda lake	35 03	115 59	1002	61 07	13 51	1.633

° This camp was upon the south side of the stream of lava which threads the valley of the Rio San José.
† This station was under the northern bluff of El Moro.
‡ Much lava in the vicinity of this station.

TABLE III.

Magnetic observations from various sources, not heretofore published, and collected for this discussion.

Name of place.	Latitude.	Longitude.	Declination.	Date.	Authority.
	° ′	° ′	° ′		
Heiner's Run, North Branch Susquehanna, Pa.	41 21	77 48	+ 3 19 W.	1856	S. Tyndale.
Kelly's island, west end Lake Erie	41 36	82 43	— 2 13 E.	1846	U. S. Top. Engineers.
East Sister isle, west end Lake Erie	41 49	82 51	— 2 18	1847	Do.
West Sister isle, west end Lake Erie	41 44	83 06	— 2 20		Do.
Stoney Point	41 56	83 15	— 2 07	1848	Do.
Wangoshane Point, Mackinac strait	45 45.4	84 55.8	— 2 13	1853	Do.
East of Duncan city, Mackinac strait	45 36.1	84 07.2	— 1 53	1851	Do.
Near Newport, Franklin county, Mo.	38 34	91 06	— 9 21	1839	Dr. Goebel.
Do. do.	"	"	— 9 05	1849	Do.
Fort Union	48 00	103 59	— 16 48	1853	Gov. I. I. Stevens, N. Pacific Railroad Explorations.
Fort Benton	47 52	110 36	— 19 00	"	
Fort Owen	46 31	113 58	— 19 25	"	
Fort Walla-Walla	46 04	118 48	— 19 40	"	
Panama, New Granada	8 57.2	79 29.4	— 6 54 6	1849	Mexican Boundary Sur.

TABLE IV.

Residual differences between the Coast Survey observations reduced to 1850, *and the values obtained from the accompanying map.*

No.	Station.	Declination.		Dip.		Hor. Intensity.	
		° ′	° ′	° ′	° ′		
1	Mount Harris	+ 14 06	— 0 6	76 02	+ 0 4	3.28	— 0.04
2	Ragged Mountain	13 54	— 27	75 32	+ 13	3.37	— .06
3	Camden Village	13 36	— 8	75 32	+ 12	3.37	— .05
4	Mount Sebattis	12 35	— 6	75 35	+ 8	3.43	— .09
5	Mount Pleasant	14 24	— 2 48	75 59	— 20	3.22	+ .15
6	Cape Small	11 57	+ 19	74 58	+ 32	3.40	— .01
7	Mount Independence	11 45	— 3	75 24	+ 3	3.36	+ .05
8	Burlington	9 29	+ 1	75 44	+ 10	3.46	— .11
9	Bowdoin hill	11 32	+ 9	75 11	+ 10	3.46	— .03
10	Richmond Island	12 15	— 40	75 07	+ 8	3.46	— .01
11	Fletcher's Neck	11 14	+ 10	75 17	+ 1	3.44	+ .02
12	Kennebunk port	11 15	— 6	75 11	— 2	3.46	+ .02
13	Mount Agamenticus	10 21	+ 30	74 57	+ 6	3.45	+ .05
14	Cape Neddick	11 00	— 1	74 55	+ 8	3.53	— .03
15	Pattucawa	10 45	— 27	76 50	— 1 50	3.02	+ .51
16	Kittery Point	10 27	+ 15	74 56	+ 4	3.50	+ .02
17	Mount Unkonoonuc	9 10	+ 37	75 10	— 19	3.47	+ .09
18	Isle of Shoals	10 15	+ 26	74 46	+ 8	3.47	+ .07
19	Plum island	10 02	+ 19	74 53	— 8	3.53	+ .04
20	Annis Squam	11 39	— 1 21				
21	Beacon hill	11 23	— 1 5	74 27	+ 9	3.62	— .02
22	Baker's island light	12 18	— 2 18	74 19	+ 14	3.69	— .08
23	Fort Lee	10 16	— 16				
	"	10 21	— 21	75 26	— 53	3.53	+ .08
24	Coddon's hill	11 51	— 1 48				
25	Little Nahant	9 43	+ 8	74 30	— 3	3.55	+ .09
26	Dorchester heights	9 48	— 9	74 16	+ 5	3.58	+ .07
	" "	9 45	— 6	74 18	+ 3	3.57	+ .08
27	Nantasket	9 49	— 4	74 18	+ 2	3.56	+ .09
28	Blue hill	9 35	— 5	75 10	— 52	3.50	+ .17
29	Beacon Pole hill	9 53	— 50	74 27	— 18		
30	Manomet hill	9 38	+ 10	74 34	— 27	3.62	+ .09
	"	"	"	74 04	+ 3		
31	Copecut hill	9 35	— 29	74 14	— 20		
32	Spencer's hill	9 32	— 41	75 13	— 1 20		
33	Shootflying hill	9 58	— 16	74 28	— 34	3.64	+ .10
	"	9 57	— 15	74 00	— 6	3.65	+ .09

The sign + or — shows how the residual is to be applied to the observed value to give that on the map.

TABLE IV—Continued.

No.	Station.	Declination.		Dip.		Hor. Intensity.	
		° ′	° ′	° ′	° ′		
34	Hyannis	9 39	+ 0 4	73 51	0 0	3.67	+ 0.07
35	Fairhaven	9 15	— 9	74 44	— 55	3.57	+ .19
36	Tarpaulin cove	9 17	— 17	73 53	— 10	3.68	+ .10
37	Indian hill	9 06	+ 7	73 46	— 5	3.71	+ .08
	"	9 06	+ 7	73 32	+ 9	3.71	+ .08
38	Sampson's hill	9 06	+ 15	73 28	+ 11	3.74	+ .05
39	Nantucket	9 31	+ 2	73 49	— 12	3.64	+ .14
	"	9 31	+ 2	73 49	— 12	3.66	+ .16
40	McSparran's hill	9 16	— 25	73 53	— 10		
41	Point Judith light	9 11	— 41	73 47	— 10	3.78	+ .02
42	Providence	9 02	— 5	74 05	— 2	3.63	+ .11
43	Watch hill	7 45	+ 30				
44	Stonington	8 00	+ 9	73 30	+ 8		
45	Groton point	7 51	+ 10				
46	Saybrook	7 12	+ 30	74 40	— 1 9		
47	Greenport	7 37	— 4	73 02	+ 22		
48	Sachem's head	6 37	+ 44				
49	Fort Wooster	7 39	— 30	74 19	— 49	3.66	+ .21
	"	7 32	— 23	74 14	— 44	3.60	+ .27
50	Oyster point	6 38	+ 28	73 34	— 4	3.76	+ .11
	"	6 35	+ 31	73 33	— 3	3.73	+ .14
51	New Haven	6 42	+ 27	73 33	— 2	3.78	+ .08
52	Milford	7 00	+ 3				
53	Bridgeport	6 41	+ 10	73 26	— 2		
54	Black rock	7 15	— 33				
55	Norwalk	7 16	— 43	73 15	+ 6		
56	Stamford	7 02	— 41	73 08	+ 11	3.86	+ .06
57	Saw-pits	6 24	— 12	72 59	+ 15		
58	Drowned meadow	6 25	+ 23				
59	Lloyd's harbor	6 38	— 14	72 56	+ 16	3.84	+ .10
60	Oyster bay	7 17	— 1 2	73 04	+ 3	3.87	+ .08
61	New Rochelle	5 56	+ 1	72 49	+ 18	3.82	+ .14
62	Sands' Point	7 36	— 1 33				
	"	6 21	— 18				
63	Legget	5 52	— 7	72 55	+ 10	3.97	.00
64	Greenbush	7 26	— 2	74 59	— 26	3.63	+ .03
65	Cold spring	5 05	+ 1 10	73 43	— 5	3.83	+ .03
66	Bloomingdale Asylum	5 28	+ 20	72 43	+ 25	4.00	— .02
67	Columbia College, N. Y	6 40	— 1 11	72 43	+ 14		
	" "	6 47	— 1 4				
68	Governor's island	6 11	— 38	72 35	+ 20	3.97	+ .03
69	Bedloe's island	6 34	— 1 4	72 48	+ 6	3.96	+ .05
70	Receiving reservoir	6 00	— 15	72 33	— 31	3.98	— .04
71	Newark	5 53	— 20	72 56	— 4	3.95	+ .03
72	Mount Prospect	6 13	— 31	72 31	+ 29	4.04	— .06
73	Cole	5 55	— 34	72 38	+ 9	4.02	+ .01
74	Sandy Hook	6 13	— 43	72 43	+ 2	4.05	— .01
	" "	5 43	+ 13	72 41	+ 4	3.96	+ .08
75	Mount Rose	5 19	— 31	72 37	0	4.15	— .09
76	White Hill	4 44	— 5	72 07	+ 17	4.14	— .04
77	Vanuxem	4 45	— 15	72 26	+ 2	4.06	+ .05
78	Girard College	4 09	0	72 05	+ 11	4.13	+ .01
	" "	4 03	+ 6	72 06	+ 10	4.27	— .13
79	Yard	6 18	— 2 21	72 52	— 36	3.91	+ .23
80	Chew	4 03	0	72 18	— 11	4.09	+ .07
81	Tucker's island	4 43	— 4				
82	Tuckerton			72 26	— 26		
83	Wilmington	2 49	+ 50	71 29	+ 35	4.22	— .04
84	Sawyer	3 06	+ 33	72 01	— 1	4.16	+ .03
85	Church Landing	6 07	— 2 25	71 26	+ 31	4.30	— .10
86	Fort Delaware	3 35	— 2	71 38	+ 14	4.22	— .01
87	Hawkins	3 16	+ 26	71 46	— 1	4.21	+ .02
88	Pine Mount	3 32	+ 7	71 45	— 1	4.23	+ .01
89	Bombay Hook light	3 36	— 6	71 43	— 3	4.19	+ .06
90	Port Norris	3 22	+ 29	71 43	— 6	4.20	+ .05
91	Egg Island light	3 20	+ 22	71 49	— 17	4.20	+ .06
92	Town Bank	3 16	+ 29	71 27	— 8	4.26	+ .03
93	Cape May light, (old)	3 23	+ 19	71 29	— 7	4.24	+ .06
	" " (new)	3 17	+ 25	71 23	— 1	4.22	+ .08
94	Lewes' Landing	3 01	+ 23				
95	Pilot Town	3 00	+ 27	71 22	— 11	4.28	+ .06

No.	Station.	Declination.		Dip		Hor. intensity.	
		° ′	° ′	° ′	° ′		
96	Osborne's Ruin	+ 2 55	— 4	71 52	— 10	4. 12	+ .13
97	Susquehanna light	2 27	+ 37	71 55	— 7	4. 08	+ .16
98	Finlay	2 37	— 4	71 57	— 19	4. 04	+ .22
	"	2 37	— 4	71 49	— 1	4. 16	+ .10
99	Pool's island	2 42	+ 3	71 55	— 18	4. 11	+ .17
100	Rosanne	2 34	— 13	72 11	— 37	4. 03	+ .26
101	Fort McHenry	2 32	— 2				
102	North Point	1 57	+ 43	71 33	— 4	4. 17	+ .13
	"	1 53	+ 40				
103	Bodkin light	2 19	+ 14	71 46	— 17	4. 18	+ .12
104	Kent island, (1)	2 33	+ 6	71 17	+ 5	4. 21	+ .11
105	South base, Kent island	2 47	— 20	71 41	— 29	4. 19	+ .16
106	Taylor	2 37	— 13	71 45	— 26	4. 21	+ .12
	"	2 31	— 07	72 22	— 3	4. 21	+ .12
107	Marriott	2 27	+ 15	71 14	— 5	4. 25	+ .11
	"	2 07	+ 5	71 13	— 4	4. 23	+ .13
108	Webb's Hill	2 03	— 15	71 22	+ 2	4. 29	+ .03
109	Soper's Hill	2 04	— 1	71 55	— 31	4. 14	+ .19
110	Hill's Hill	2 15	— 15	71 11	+ 1	4. 31	+ .05
111	Causten's Hill	1 04	+ 44	71 16	— 4	4. 23	+ .13
	" "	0 38	+ 1 10	71 19	— 7	4. 28	+ .08
	" "	0 37	+ 1 11				
112	Washington city	5 38	— 3 71	71 16	— 6	4. 38	— .01
113	Davis	2 14	+ 1 1	70 50	— 2	4. 35	+ .06
114	Roslyn	0 13	+ 32	69 12	+ 21	4. 64	+ .02
115	Stevenson's Point	1 53	— 44	68 58	— 22	4. 65	+ .14
116	Shellbank	1 57	— 27	68 40	— 4	4. 70	+ .09
117	Bodies island	1 27	+ 3	68 21	+ 3	4. 74	+ .08
118	Raleigh, N. C.	1 03	+ 11	68 04	— 7	4. 97	— .03
119	De Rosset	1 30	+ 27	66 38	— 6	5. 20	— .04
120	Columbia, S. C.	3 18	+ 12	66 00	— 9	5. 30	0
121	Allston	2 22	+ 10	65 22	+ 7	5. 43	— .08
122	Macon, Ga			63 41	+ 28		
123	Breach inlet	2 14	— 34	64 32	+ 14	5. 46	0
124	East base, Edisto island	2 54	— 9	64 04	+ 23	5. 53	0
125	Savannah	3 49	+ 10	63 35	+ 13	5. 62	0
126	Tybee island	3 41	+ 8	63 34	+ 14	5. 60	+ .03
127	Cape Florida	4 25	— 8	56 13	+ 8	6. 61	— .09
128	Sand key	5 29	+ 5	54 26	+ 1	6. 76	+ .07
129	Depot key	5 22	+ 12	59 55	+ 8	6. 15	+ .04
130	St. Mark's light	5 31	+ 1				
131	Dog island	5 53	+ 10				
132	St. George's island	6 04	+ 10				
133	Cape St. Blas	6 08	+ 4				
134	Hurricane island	6 14	+ 6				
135	Fort Morgan	7 03	— 1			6. 21	0
136	East Pascagoula	7 13	— 1	60 30	— 3	6. 20	0
	" "	7 09	+ 3			6. 14	+ .06
137	Montgomery	5 06	— 1 4	62 52	+ 20	5. 89	— .10
138	Fort Livingston	7 40	— 4				
139	Belle Isle						
140	Isle Dernière	8 20	+ 17				
141	Dollar Point	— 8 57	— 7	57 53	+ 7	6. 53	— .04
142	East base	9 07	— 4	57 42	— 3	6. 52	+ .02
143	Jupiter	9 10	— 5	57 12	— 6	6. 59	0
144	Rio Grande	9 02	— 5	52 23	— 7		
145	San Diego	12 28	— 21				
	" "	12 32	— 25	57 38	+ 33	6. 30	— .04
146	San Pedro	13 37	+ 18	59 32	— 17	6. 17	— .01
147	Point Conception	13 50	+ 5				
148	San Luis Obispo	14 13	+ 6	59 42	+ 45	6. 03	— .03
149	Point Pinos	14 57	0				
150	San Francisco	15 25	— 10				
151	Bucksport	17 03	— 14				
152	Humboldt	17 00	— 16				
153	Ewing harbor	18 28	+ 6				
154	Cape Disappointment	20 19	+ 22				
155	" "	20 45	— 4				
156	Scarboro' harbor	21 27	— 7				
157	Waddah island, Neé-ah bay	21 41	+ 8	71 07	0	4. 32	0

APPENDIX No. 29.

Report of Assistant Charles A. Schott, on magnetic observations made at stations in Delaware, Maryland and Virginia.

WASHINGTON CITY, *September* 28, 1856.

DEAR SIR: In accordance with your instructions of July 14, relative to the magnetic survey, I have the pleasure of informing you that I succeeded in determining the magnetic elements at seventeen stations in Section III.

Special pains were taken to secure the values of constants for the absolute intensity and the corrections applicable to the dipping needles. After reweighing and remeasuring the intensity rings and adjusting the length of the deflecting bar, seven values of K, the moment of inertia of magnet H, were obtained by means of three inertia rings, very different in weight, with results practically identical. The temperature co-efficient (q) had been previously determined by Assistant Hilgard. Six values for P, the co-efficient depending on the distribution of magnetism, were obtained before leaving Washington, and three additional ones after my return. The magnetic moment m of magnet H was determined, before and after the magnetic survey, from twelve independent sets of observations. In order to test the figure of the axles of the dipping needles, I loaded the needles, as proposed by Kupfer, applying Mayer's formula, and observed with each needle fourteen sets, each set consisting of thirty-two readings, with polarity direct, and the same number with polarity reversed. An arc of more than 220° of the circumference of the axle has thus been tested. The observations for determination of constants were made near the Coast Survey office, and this station, or that at the Capitol, may serve for the future comparison of instruments. The first computation of the constants by myself, and the second by Mr. Main, are nearly completed.

At each of the seventeen stations occupied, the azimuth and time (for the declination) were determined from three sets of observations of the sun, when near the prime vertical, observing upper and lower, and first and second limbs, alternately, making seventy-two separate readings in all. The five-inch horizontal and vertical circles proved sufficiently accurate for the purpose. The absolute intensity being known, the relative intensity was obtained by means of two full sets of vibrations of magnet H. The dip was determined by two needles and four sets, giving in all two hundred and fifty-six separate results—each set comprising thirty-two readings, with polarity direct, and an equal number with polarity reversed. These two needles have been compared with four other needles.

The following stations were occupied (in the order of time) between August 21 and September 24, 1856:

1. Coast Survey office, Washington city.
2. East Capitol garden, Washington city.
3. Oxford, Md.
4. Cape Henlopen light-house.
5. Dagsborough, near Indian river.
6. Mason's Landing.
7. Snead.
8. Joynes.
9. Scott.
10. Cape Charles.
11. Old Point Comfort light-house.
12. Norfolk, northern station.
13. Norfolk, southern station.
14. Cape Henry light-house.
15. Fort McHenry, Baltimore.
16. Brown's island, Fredericksburg.
17. Mayo's island, Richmond.

It was found impracticable to reach the lower Rappahannock at the date last mentioned; and having occupied one station additional to the number enumerated in your instructions, I returned to the office, where my presence had become necessary, resuming charge of the Computing division on the 25th instant. I have to acknowledge the services of Mr. J. L. Tilghman, who aided as recorder of the observations.

I am now engaged in putting the record, in proper shape and in calculating the results, which, in view of other duty, will occupy some weeks.

I remain, sir, yours very respectfully,

CHAS. A. SCHOTT,
Assistant Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX NO. 30.

Results of observations made by Assistant Charles A. Schott, Computing division Coast Survey office, for magnetic declination, dip, and horizontal intensity, in Section III—1856.

No. of stat'n.	Name of station.	Date.	Latitude.	Longitude.	Declination W.	Dip.	Horizon'l intensity.	Total inten'y
		1856.	° ′	° ′	° ′	° ′		
1°	Coast Survey office, Washington	August 14 & 20.	38 53.1	77 00.2	2 21.4	71 21.6	4.309	13.48
2	East Capitol garden, Washington	August 15	38 53.3	77 00.1	2 01.0	71 19.6	4.308	13.46
3	Oxford, Md	August 23	38 41.4	76 10.2	2 41.3	70 57.9	4.384	13.44
4	Cape Henlopen light, Del.	August 27	38 46.5	75 04.9	3 03.7	71 22.0	4.285	13.41
5†	Dagsborough, Del.	August 28	38 35.7	75 15.3	2 40.6	71 03.1	4.348	13.39
6	Mason's Landing, Md.	August 30	38 13.8	75 14.7	2 22.9	70 44.8	4.405	13.36
7	Snead, Va.	September 2	37 58.3	75 25.9	2 18.8	70 31.0	4.449	13.34
8	Joynes, Va.	September 4	37 41.6	75 36.6	2 03.2	70 21.2	4.488	13.35
9	Scott, Va.	September 6	37 20.5	75 53.8	1 37.4	70 01.5	4.572	13.38
10	Cape Charles, Va.	September 7	37 07.3	75 57.9	1 35.3	69 43.3	4.624	13.34
11	Old Point Comfort, Va.	September 8	37 00.0	76 18.1	1 14.7	69 31.7	4.660	13.32
12	Norfolk, northern station	September 9	36 51.4	76 17.2	1 39.2	69 29.7	4.658	13.30
13	Norfolk, southern station	September 10	36 50.5	76 16.8	1 33.3	69 28.8	4.667	13.31
14	Cape Henry light, Va.	Sept. 11 & 12	36 55.6	76 00.1	1 27.9	69 39.0	4.621	13.29
15	Fort McHenry, Baltimore, Md.	September 13	39 15.9	76 34.8	2 29.2	71 45.7	4.203	13.43
16	Brown's island, Fredericksburg, Va.	September 17	38 18.2	77 27.2	1 01.9	70 37.8	4.450	13.42
17	Mayo's island, Richmond, Va.	September 19	37 31.7	77 25.7	0 14.8	69 48.3	4.609	13.35

° Occupied for determination of magnetic constants, August 11, September 22, 23, and October 15.

† Latitude and longitude determined astronomically.

APPENDIX No. 31.

An attempt to determine the secular change of the magnetic declination on the Western Coast of the United States: by Chas. A. Schott, in charge of the Computing division, Coast Survey office.

COMPUTING DIVISION,
Coast Survey Office, April 21, 1856.

DEAR SIR: The general discussion of the results of the magnetic observations of the survey, the publication of which was commenced in the Superintendent's annual report for 1855, requires for its continuation the secular change of the three magnetic elements on the Western Coast, and an attempt is here made to deduce the same for the declination, from the scanty material on hand.

Although the material collected will not admit of a systematic treatment, such as was carried out for the Eastern Coast of the United States, yet enough remains to assign to the more recent observations a tolerably reliable epochal correction, necessary for tracing out the isogonic lines.

Independent of this purpose, however, the important bearing of a study of the secular change on the law of terrestrial magnetism itself, has already been pointed out in the paper above referred to. The following list of results for magnetic declination on the Western Coast, from the earliest times to the present, has been carefully compiled. It includes but a few observations made on shipboard, and those taken close to the coast are marked by an asterisk. In general, the observations taken at sea are too unreliable on account of the effect of local attraction, from which the older observations cannot be freed. There seems to have been a disposition in the earlier navigators to observe "off the coast," in preference to "on shore," for fear of the *land attraction*, as it was called.

List of magnetic declinations observed on the Western Coast, from the earliest times to the present, arranged in the order of the geographical latitude of the stations.

No.	Name of place.	itude, N.	Longitude, W.	Year.	Month.	E. declination.	Observer.	Authority or reference.	Remarks.
		° ′	′			° ′			
1	San Diego	32 39	117 17	1792		11 00	Vancouver	Hansteen's Magnetismus der Erde, 1819.	The longitude is nearly correct.
	Do°	32 30	120 46	1793	Jan. 15	12 00	do	do do	Off the coast.
	Do°	34 42	116 53	1793	December	11 00	do	do do	The latitude is incorrectly given as 34° observation, near or on coast.
	Do	32 41	117 13	1839		12 20.6	Belcher	Phil. Trans. Roy. Soc., 1841. P.I.	
	Do	32 40	119 37	1841		11 00	Duflot de Mofras	Exploration of Oregon	2 vols. Paris, 1844. The longitude is from Paris.
	Do	32 42	117 13	1851	Apl. 28, May 7	12 28.8	Davidson	U. S. Coast Survey	At the C. S. Observatory.
	Do	32 42	117 13.3	1853	October 15	12 31.7	Trowbridge	do	At the Plaza, near custom-house.
2	San Pedro	33 43	118 15	1839		13 08.5	Belcher	Phil. Trans. Roy. Soc., 1841	
	Do	33 46	118 16	1853	Nov. 25	13 30.5	Trowbridge	U. S. Coast Survey	Three miles north of San Pedro.
3	Santa Barbara	34 24	119 16	1793	November	10 15	Vancouver	Hansteen's Magnetismus der Erde,	Probably taken on shore.
	Do	34 24	119 41	1839		13 28.0	Belcher	Phil. Trans. Roy. Soc., 1841	
4	Point Conception			1791	Nov. 21	14 52		Ency. Brit., 7th edition, 1842	This declination is undoubtedly too great.
	Do	34 26.9	120 25.6	1850	Sept. 5 & 8	13 50.2	Davidson	U. S. Coast Survey	At the mouth of El Coxo valley.
5	San Luis Obispo	35 10.6	120 43.5	1854	Jan. 30, Feb. 7	14 16.9	Trowbridge	U. S. Coast Survey	
6	Monterey			1790	Sept. 23	10 56	Malaspina	Berlin Ast. Jahr., vol 53, for 1828.	Observation made on shore.
	Do	36 36	121 34	1792	December	12 22	Vancouver	Hansteen's Mag. der Erde	Probably taken on shore.
	Do	36 36	121 51	1795		12 22	do	do do	
	Do			1837		14 30	Du Petit Thouars	Voyage of the frigate Venus	Near Monterey.
	Do	36 36	121 53	1839		14 13.0	Belcher	Phil. Trans. Roy. Soc., 1841	
	Do	36 36	124 13	1841		15 00	Duflot de Mofras	Exploration of Oregon	At Presidio of Monterey. The longitude is from Paris.
	Do	36 38	121 54.4	1851	February 8	14 58.3	Davidson	U. S. Coast Survey	At Point Pinos Observatory.
7	San Francisco	37 48	122 08	1792	Nov. 20	12 48	Vancouver	Hansteen's Mag. der Erde	Probably taken on shore.
	Do			1824		16 00	Kotzebue	Becquerel	Traité complet de Magnetisme. Paris, 1846.
	Do			1827		15 27	Beechey	Becquerel	Traité complet de Magnetisme. Paris, 1846.
	Do			1829		15 06	Erman	Becquerel	Traité complet de Magnetisme. Paris, 1846.
	Do	37 48	122 23	1837		15 20.0	Belcher	Phil. Trans. Roy. Soc., 1841	
	Do			1837		15 00	Du Petit Thouars	Voyage of the frigate Venus	
	Do	37 48	122 23	1839		15 20.0	Belcher	Phil. Trans. Roy. Soc., 1841	
	Do	37 49	124 48	1841	October	15 30	Duflot de Mofras	Exploration of Oregon	The long. is from Paris.
	Do	37 49	124 48	1842	January	15 30	do	do do	do. do.
	Do	37 47.6	122 26.8	1852	Feb. 23	15 26.9	Davidson	U. S. Coast Survey	Near the Presidio.

List of magnetic declinations, &c.—Continued.

No.	Name of place.	Latitude, N.	Longitude, W.	Year.	Month.	E. declination.	Observer.	Authority or reference.	Remarks.
		° ′	° ′			° ′			
8	Port Bodega	38 18	123 02	1839		15 20.0	Belcher	Phil. Trans. Roy. Soc., 1841	
	Do	38 18	125 24	1842		16 00	Duflot de Mofras	Exploration of Oregon	Longitude is from Paris.
9	Shelter Cove°	40 03	124 09	1792	April 19	15 00	Vancouver	Hansteen's Mag. der Erde	Probably taken on shore.
10	Cape Mendocino	40 29	124 29	1693		2 00	Carreri	Hansteen's Mag. der Erde	
	Do	40 29	124 29	1786	Sept. 8	14 24	La Perouse	do do	Same place as above.
	Do°	40 32	124 82	1792	April 22	16 00	Vancouver	do do	Near the cape.
11	Bucksport	40 46.6	124 10.7	1854	July 20	17 06.5	Davidson	U. S. Coast Survey	On the beach, Humboldt bay.
	Do	40 44.7	124 11.0	1854	Apl. 25 { May 2 }	17 04.5	do	do	At C. S. station, Humboldt.
12	Trinidad	41 07	126 36	1841		16 00	Duflot de Mofras	Exploration of Oregon	The latitude is 4′ too great. The longitude from Paris.
13	Ewing Harbor	42 44.4	124 12.8	1851	Nov. 24	18 29.7	Davidson	U. S. Coast Survey	Near Cape Orford.
14	Cape Blanco°	43 06	124 18	1792	April 25	16 00	Vancouver	Hansteen's Mag. der Erde	Near the cape.
15	Cape Foulweather°	44 42	124 07	1792	April 26	18 00	Vancouver	Hansteen's Mag. der Erde	Near the cape.
16	Fort Vancouver	45 37	122 36	1839		19 22.0	Belcher	Phil. Trans. Roy. Soc., 1841	On Columbia river.
17	Cape Disappointment°	46 14	123 59	1792	April 27	18 00	Vancouver	Hansteen's Mag. der Erde	} Near the mouth of Columbia river.
	Do°	46 19	123 53	1792	December	20 00	do	do do	
	Do	46 17	124 02	1839		19 11.0	Belcher	Phil. Trans. Roy. Soc., 1841	On Baker's bay, mouth of Columbia river.
	Do			1842		20 00	Duflot de Mofras	Exploration of Oregon	At mouth of Columbia river.
	Do	46 16.6	124 02	1851	July 7	20 19.1	Davidson	U. S. Coast Survey	On the beach.
	Do	46 16.6	124 02	1851	July 17	20 45.3	do	do	On top of cape.
18	Gray's Harbor°	47 00	123 53	1792	December	18 00	Vancouver	Hansteen's Mag. der Erde	Off the harbor.
19	Port Discovery	48 02	122 38	1792	May	21 30	Vancouver	Hansteen's Mag. der Erde	The longitude is about ½° too small. Probably on shore.
20	Neé-ah bay°	48 19	123 41	1792	April 30	18 00	Vancouver	Hansteen's Mag. der Erde	Juan de Fuca Straits.
	Do	48 21.8	124 37.2	1852	August 20	21 29.9	Davidson	U. S. Coast Survey	Near Cape Flattery.
	Do	48 22.0	124 36.6	1855	August 15	21 46.9	Trowbridge	do	Near Waddah island.

The above list contains 55 separate observations for declination.

The discussion of these results is best preceded by a short historical review. The first chart, exhibiting the isogonic lines of the southern part of the Western Coast, was constructed by Professor Christopher Hansteen for the year 1710; and, according to it, the eastern declination was 4½° at San Diego. By comparison, the observation at Cape Mendocino in 1693, where Gemini Carreri found 2° E., appears to be too small by a few degrees.

The next map refers to 1744; here we find the eastern declination at San Diego nearly 7½°, and about 11° at Cape Mendocino.

On the map for 1770, San Diego is on the line 10½° E., which accords well enough with Vancouver's determination in 1792, when corrected for secular change. Cape Mendocino has an eastern declination between 14° and 17°, and is a few degrees too high, when compared with La Perouse's observation in 1786.

On these maps, however, all the latitudes are about 2½° too high, owing to a singular practice of the Spanish explorers of those times, and undoubtedly growing out of their ambition to give to their explorations an apparently great northward expanse. This circumstance has been taken into consideration in the above measures, and had the effect of increasing the declination on the average by about 1°. The longitudes are very nearly correct.

For Hansteen's principal map, that of 1787, Vancouver furnished abundant material to give a reliable system of isogonic lines, and accordingly we find as close an agreement between the values in that map, and those from the table, as is compatible with the scale of the map, and the still uncertain allowance for secular change; the latitudes also agree much better with the modern determinations.

The isogonic lines on the earlier maps, constructed by interpolation from analogy, and supported by the observation at Cape Mendocino, near the close of the 17th century, leave no doubt on the conclusion that throughout the 18th century the eastern declination on the Western Coast has been gradually increasing; and its average annual amount, though necessarily very uncertain, is given in the following table:

Locality.	Declination.	Annual increase.
	°	′
San Diego in ------ 1710	— 4.5	------------
1744	— 7.5	5.3
1770	— 10.5	6.9
1792	— 11.0	1.7
Cape Mendocino in 1693	— (2.0)?	
1710	— 6.0	(13.8)?
1744	— 11.0	7.3
1786	— 14.4	4.8

5′.4 may be set down as the average annual increase. We notice, besides, in the second half of the century, a tendency to a diminution, which latter fact is supported by the modern observations, as will be seen further on. Between 1700 and 1750, therefore, the annual increase may approximately be assumed as 6′.6, and between 1750 and 1790 as about 4′.0.

Whether the needle ever pointed to the west of the true meridian on the Western Coast of the United States, between 1600 and 1700, must at present remain a matter of conjecture.

There is another result which the above data bear out, namely, the diminution of the secular change when approaching, and the reverse when receding from, the equator. For the southern coast of California, the above figures expressing the annual change may be diminished by ¼, and increased by the same amount for the northern coast. This decreased variation, corresponding to an approach toward the equator, has been clearly established for the eastern coast of the United States.

An inspection of the general table of declinations shows that we must wait for further material in order to discuss successfully the observations since 1792. The three epochs—that of Vancouver about 1792, of Sir E. Belcher in 1839, and of the Assistants of the Coast Survey since 1850, will barely permit us to introduce a second term, that of curvature, in the expression for the secular change; and for most of the stations we must rest satisfied with a first term only or a straight line discussion.

Let us consider the stations separately:

1. *San Diego.*—At this place we exclude the second and third observations as given in the general table. The mean epoch, 1830, is the same as that of the corresponding discussion for the Eastern Coast; and, as before, eastern declination is indicated by a negative sign prefixed. The treatment by the method of least squares leads to the expression—

$$D = -11^\circ.27 - 0.0353\ (t - 1830) - 0.00075\ (t - 1830)^2$$

which represents the observations as follows:

Year.	D observed.	D computed.	
	°	°	°
1792.5	— 11.00	— 11.00	0.00
1839.5	— 12.34	— 11.67	+ 0.67
1841.5	— 11.00	— 11.78	— 0.78
1851.4	— 12.48	— 12.37	+ 0.11
1853.8	— 12.53	— 12.51	+ 0.02

and if we reject the 5th observation, which appears too small by at least 1°, we obtain the formula—

$$D = -12^\circ.17 - 0.019\ (t - 1830) + 0.00018\ (t - 1830)^2$$

which is considered preferable to the first. It represents the observations as follows:

Year.	D observed.	D computed.	Δ
	°	°	°
1792.5	— 11.00	— 10.99	+ 0.01
1839.5	— 12.34	— 12.34	0.00
1851.4	— 12.48	— 12.48	0.00
1853.8	— 12.53	— 12.52	+ 0.01

The sign of the quadratic term indicates a gradual diminution in the present annual increase, agreeably to what has been found before.

2. *Monterey.*—Uniting the mean of the second and third observations with the first, and also uniting the fourth and fifth observations, the resulting declination can be represented by

$$D = -14^\circ.19 - 0.0502\ (t - 1830) + 0.00047\ (t - 1830)^2$$

which expression leaves the following differences between the observed and computed values:

Year.	D observed.	D computed.	Δ
	°	°	°
1792.5	— 11.65	— 11.66	— 0.01
1838.5	— 14.36	— 14.58	— 0.22
1841.5	— 15.00	— 14.70	+ 0.30
1851.1	— 14.97	— 15.03	— 0.06

The omission of De Mofras's observation would produce no very sensible difference in the resulting equation, viz:

$$D = -13^\circ.91 - 0.0534\ (t - 1830) + 0.00019\ (t - 1830)^2.$$

3. *San Francisco.*—At this place, after uniting the first two observations, those of 1827 and 1828, those of 1837, and those of 1841 and 1842, respectively, the expression for the secular change becomes:

$$D = -15^\circ.14 - 0.0282\ (t - 1830) + 0.00025\ (t - 1830)^2$$

which represents the individual results as follows:

Year.	D observed.	D computed.	Δ
	°	°	°
1808.7	− 14.40	− 14.43	− 0.03
1828.5	− 15.27	− 15.10	+ 0.17
1837.5	− 15.17	− 15.36	− 0.19
1839.5	− 15.33	− 15.38	− 0.05
1841.9	− 15.50	− 15.44	+ 0.06
1852.2	− 15.67	− 15.64	+ 0.03

The agreement seems quite satisfactory.

4. *Cape Mendocino.*—The interval of 1693.5 and 1786.5 being too great to assume the same law to hold good as for the present century, and there being no data of such early date available at other stations for verification, the declination for 1693.5 has not been introduced in the formula. La Perouse appears to have observed at a place to the southward of the cape.

The observation of 1792.3 can be referred to the latitude of the Cape by means of the observation at or near Shelter cove, by the same navigator, and at the same time, viz: in latitude 40° 03′, longitude 124° 19′, declination 15° 00′; hence, for Cape Mendocino, latitude 40° 27′, longitude 124° 33′, the declination becomes 15° 50′.

The formula—

$$D = +16^\circ.58 \text{ east} + 0.497\ (L - 39^\circ.97) + 0.151\ (M - 122^\circ.40) + 0.0069\ (L - 39.97)^2$$

established in November, 1855, represents within a few minutes the observed declinations of nine stations situated between San Diego and Cape Flattery, and gives the declination for Cape Mendocino $-17^\circ.12$, for the epoch 1852.1. Assistant G. Davidson's observations in 1853, July 20, at Humboldt bay, when referred to Cape Mendocino, by means of the above formula, gives $-16^\circ.97$ (for 1853.5.) We have, therefore, for the present:

Declination in 1786.5	−14°.40
1792.3	−15 .83
1853.5	−16 .97

which can be represented by

$$D = -19^\circ.55 + 0.030\ (t - 1830) + 0.00340\ (t - 1830)^2.$$

The incorrectness of this formula is apparent at the first glance, since the declination in 1830 could not have been $-19\frac{1}{2}^\circ$. This is owing to the apparent great change in declination between 1786.5 and 1792.3, one or the other of which results must be incorrect. In this, therefore, we are forced to assume the second co-efficient equal zero, and the observations are then represented by

$D = -16^\circ.29 - 0.029\ (t - 1830)$ which is based on a mean value for 1786.5 and 1792.3.

5. *Cape Disappointment.*—If we take a mean of the two uncertain observations of Vancouver, and likewise combine the two last observations, the four results can be expressed by the formula

$$D = -18^\circ.89 - 0.0483\ (t - 1830) - 0.0013\ (t - 1830)^2$$

which leaves the following differences between the observed and computed declinations: $+0^\circ.02$, $-0^\circ.29$, $+0^\circ.29$ and $-0^\circ.02$. The sign of the quadratic term, however, does not agree with the other formula of the preceding stations; and since the first two observations are too uncertain, I prefer to use a straight line expression, and find

$$D = -19^\circ.65 - 0.019\ (t - 1830)$$

which expression leaves differences of $\frac{1}{2}^\circ$. This station, therefore, requires more observations before we can arrive at a satisfactory result.

Recapitulation of results for secular change in the declination.

1. San Diego.................	$D = -12^\circ.17 - 0.019\ (t - 1830) + 0.00018\ (t - 1830)^2$
2. Monterey..................	$D = -14.19 - 0.050\ (t - 1830) + 0.00047\ (t - 1830)^2$
3. San Francisco............	$D = -15.14 - 0.028\ (t - 1830) + 0.00025\ (t - 1830)^2$
4. Cape Mendocino..........	$D = -16.29 - 0.029\ (t - 1830)$
5. Cape Disappointment...	$D = -19.65 - 0.019\ (t - 1830)$

For the general form $D = d_1 + x + y\ (t - 1830) + z\ (t - 1830)^2$, the mean value of the co-efficients become

$$y = -0.032 \text{ and } z = +0.00030.$$

and the annual variation, expressed in degrees,

$$v = y + 2z\ (t - 1830)$$

Hence for 1840..........................	$v = -1'.6$
1850..........................	$v = -1'.2$
1860..........................	$v = -0'.8$

The two observations at San Pedro give about the same, but the two recent observations at Neé-ah bay three times the above value. According to the deduced formula, we might expect a maximum eastern declination before or about the close of the present century; this conclusion, however, yet requires confirmation by new observations before it can safely be adopted.

Extending our investigation further south, we find acceptable results for declination at San Blas, Mexico; latitude 21° 32′ N., longitude 105° 16′ W., viz:

1791, April...	Declination	7° 28′ E.	*Encycl. Brit.*, 7th edition, 1842.
1821............	Declination	8 40 E.	Do. do.
1828............	Declination	11 06 E.	Beechey, *Becquerel's Mag'm.* Rejected, evidently erroneous.
1837............	Declination	8 34 E.	Belcher, *Phil. Trans. Roy. Soc.*, 1843.
1839............	Declination	9 00 E.	Do. do.
1841............	Declination	9 12 E.	Duflot de Mofras, *Exploration of Oregon.*

Omitting the first, the above observations can be represented by

$$D = -8^\circ.18 - 0.056\ (t - 1830) - 0.00746\ (t - 1830)^2$$

But if we unite the second and third, and include the first observation, we obtain the expression—

$$D = -8^\circ.63 - 0.042\ (t - 1830) - 0.00031\ (t - 1830)^2$$

which represents the observations remarkably well, the greatest difference being 4′.

At the city of Mexico there was an average annual increase of eastern declination of 4′.6 between 1769 (Don Alzate) and 1803, (Alex. Von Humboldt.) At Acapulco, the average annual increase was 3′.4 between 1744 (Anson) and 1838, (Belcher, Du Petit Thouars, and Duflot de Mofras.) At Vera Cruz, the annual increase of easterly declination from five observations, between 1769 and 1819, was 4′.3. At Panama, however, from five observations, between 1775 and 1849, the easterly deviation of the needle appears to have changed very little, at any rate less than a degree, and contrary to the direction found at the above stations. The character of the secular change at Jamaica has been noted in my former paper.

These short notices have been inserted, as they must finally assist in the tracing out of the *connection* of the law of the secular change of the declination, as found on the Atlantic and Gulf coast, and that of the Pacific coast of the United States—a gap which it is impossible at present to close. The following parallel may be drawn:

EPOCH.	EASTERN DECLINATION.	
	Southeastern coast of United States.	Western coast of United States.
Between 1740 and 1804	Increasing with a diminishing rate	Increasing with a diminishing rate.
About 1804	Stationary	
Between 1804 and 1850	Decreasing with an accelerating rate	

From which table, and from what has been said above, it may be conjectured that a corresponding stationary epoch for the Western Coast will yet be attained.

As it is, the present system of isogonic lines moves slowly to the southward on both the Atlantic and Pacific coasts—slower in the southern, less slow in the northern latitudes.

I remain, sir, yours, very respectfully,

CHARLES A. SCHOTT.

Capt. W. R. PALMER, *U. S. Topog. Engrs.*,
Assistant, in charge Coast Survey Office.

APPENDIX No. 32.

Discussion of the secular variation of the magnetic inclination in the northeastern States: by Chas. A. Schott, in charge of the Computing division, Coast Survey office.

COMPUTING DIVISION,
Coast Survey Office, February 26, 1856.

DEAR SIR: The following discussion of the secular variations of the magnetic inclination near the Atlantic coast, between latitude 38° and 44°, intended to form a part of the general discussion of the magnetic observations of the Coast Survey, commenced in your annual report on the operations of the survey during 1855, is herewith respectfully submitted.

While the observations for declination reach back as far as the 17th century, and are quite numerous for the latter half of the 18th, the observations for inclination are of but recent date. Near our Atlantic coast, 30 or 35 years include the whole period, taking no account of three observations about 1782, at Cambridge. Fortunately for our knowledge, the secular variation, within this short period, has passed a turning point, the epoch of which has been fully established.

Here, as in the declinations, Professor Loomis has contributed a large share in observing, collecting, and discussing magnetic dip, and we are also indebted to him for the construction of an isoclinal map. Professor Loomis says: "From these observations, (collected by him,) when compared with those of Long's expedition, we may assume the diminution of the dip from 1819 to 1839, to be at the rate of 1'.5 a year."—(Sill.'s Journal, xxxix, 1840, on the variation and dip of the magnetic needle in the United States, by E. Loomis.)

It does not appear that, later, a second effort was made to follow these changes of the dipping needle, probably on account of the small change, and the stationary period soon afterwards reached.

It must be considered as fortunate that the dip observations at the Toronto Observatory commenced as early as 1841, and therefore include the turning epoch, though from these observations alone it could not be clearly made out. Colonel Sabine remarks, (page lxxxviii of Observations made at the Magnetical and Meteorological Observatory at Toronto, Canada, vol. II, 1843–'44–'45, 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." He then goes on to show that the change may be owing to disturbances, and finally remarks : "in the meantime, considering the small amount of the apparent irregularity, together with the variety of needles employed in the observations of different years, and the consequent possibility of defective intercomparability, we may perhaps take as the best present approximation a uniform increase of inclination."

It will be seen, further on, that the first supposition, that of a minimum about 1843, was the correct one, and that this fact is supported by a number of observations at other stations, and in particular at Philadelphia, where we have another excellent series of observations which were made under your direction. This series also includes the minimum, the establishment of which, beyond doubt, may be considered as the principal result of the present investigation. From a cursory examination of the observations at New York and Cambridge, the epoch of this minimum was recognised and communicated to you in October last.

The observations used in this discussion have been collected with care, and, it is believed, include nearly all that have been published ; the results are based upon 161 separate determinations for dip. The mode of discussion and the formula used being similar to those employed in my discussion of secular variation of the declination, Coast Survey Report for 1855, (and in the proceedings of the ninth meeting of the American Association, 1855,) no further explanation is deemed requisite here.

It was found that at present the inclinations could be represented by the formula—

$$I = i_1 + x + y\,(t - t_0) + z\,(t - t_0)^2,$$

the same as used by Professor Hansteen in his paper "on the changes in the magnetic inclinations in the northern temperate zone."—Astronomische Nachrichten, Nos. 947, 948, and 954. The epoch 1840, to which the results of the separate stations were reduced in Professor Hansteen's paper, also suited the present investigation. One locality, New York, is included in both papers, of which more hereafter.

In the establishment of conditional and normal equations, and their solution, I was assisted by Mr. J. E. Blankenship.

The observations at the several stations admitting of discussion here follow :

SECULAR CHANGE OF THE MAGNETIC DIP AT TORONTO, CANADA.

Collection of observations.—In Vol. II, 1843, 1844, 1845, of "Observations made at the Magnetical and Meteorological Observatory at Toronto, in Canada," London, 1853, we find the following results for the middle of the year :

	°	′
1841	75	16.6
1842		16.4
1843		14.7
1844		14.8
1845		15.5
1846		15.1
1847		15.3
1848		18.3
1849	75	18.8

	° ′
1850	75 20.0
1851	20.4
1852	75 20.5

From other sources we have:

1843, Captain Lefroy, Sill.'s Journal, vol. iv, 1847 .... 75° 15′.5

June, 1844, Professor Locke, Trans. Amer. Phil. Soc., vol. IX, 1846, half a mile east of observatory .... 75° 12′.5

At observatory .... 75° 13′.4

These observations have been properly combined with the above, and the whole may be represented by the formula—

$$I = 75°.29 - 0.01441\ (t - 1840) + 0.001636\ (t - 1840)^2.$$

The following table contains the observed and computed inclinations:

t.	I. observed.	I. computed.	Δ
	°	°	°
1841.5	75.28	75.27	− 0.01
1842.5	75.27	75.26	− 0.01
1843.0	75.26	75.26	0.00
1843.5	75.24	75.25	+ 0.01
1844.5	75.23	75.25	+ 0.02
1845.5	75.26	75.26	0.00
1846.5	75.25	75.26	+ 0.01
1847.5	75.26	75.27	+ 0.01
1848.5	75,30	75.28	− 0.02
1849.5	75.31	75.30	− 0.01
1850.5	75.33	75.32	− 0.01
1851.5	75.34	75.34	0.00
1852.5	75.34	75.36	+ 0.02

The probable error of any single result is ± 0′.6

Secular change of the magnetic dip at Albany and Greenbush, N. Y.

				Mean dip.	Mean year.
			° ′	° ′	
April,	1833	Prof. Henry, Trans. Amer. Phil. Soc., vol. v, 1835	74 51.1	74 51.1	1833.4
Aug.,	1834	President Bache, Trans., as above	74 40.1	74 45.7	1837.1
Sept.,	1839	Prof. Loomis, Trans. Amer. Phil. Soc, vol. iii, 1840	74 51.3		
Aug.,	1841	Trans. Amer. Phil. Soc., vol. viii, 1843	74 39.9	74 42.2	1842.0
	1842	Captain Lefroy, Silliman's Jour., vol. iv, 1847	74 44.6		
	1844	Prof. Locke, Silliman's Jour., vol. iv, 1847	74 41.6	74 41.6	1844.5
June,	1844	Prof. Locke, Trans. Amer. Phil. Soc., vol. ix, 1846, at Greenbush	74 43.1		
	1844	Prof. Locke, Albany. Trans., as above	74 40.2		
Aug.,	1855	U. S. Coast Survey (Chas. A. Schott, observer) at Greenbush	75 11.3	75 11.3	1855.6

The above observations can be represented by the formula—

$$I = 74°.70 - 0.0086\ (t - 1840) + 0.00257\ (t - 1840)^2$$

which expression represents the observations as follows:

t.	I observed.	I computed.	Δ
	°	°	°
1833.4	74.85	74.86	+ 0.01
1837.1	74.76	74.74	− 0.02
1842.0	74.70	74.69	− 0.01
1844.5	74.69	74.71	+ 0.02
1855.6	75.19	75.19	0.00

The probable error of any single result is ± 0′.9.

Secular change of the magnetic dip at Cambridge, Mass.

				Mean dip.	Mean year.
			° ′	° ′	
Dec.,	1780	Dr. Williams, Mem. Amer. Aca., vol. ii, new series, 1846; also, Ency. Met., 1848	69 51.0		
June,	1782	Same as above. These three observations have been omitted in the discussion as not sufficiently connected with the rest.*	69 41.0		
Dec.,	1783	Same as above.	69 41.0		
Sept.,	1839	Trans. Amer. Phil. Soc., vol. vii, P. I, 1840; Prof. Loomis	74 20.1	74 18.4	1839.7
	1839	Trans. Amer. Phil. Soc., vol. viii, P. I, 1840; Prof. Loomis, at Dorchester	74 16.0		
	1839	Same place, Silliman's Jour., vol. xxxix; Bond	74 19.0		
	1840	Lovering & Bond, Mem. Amer. Aca., vol. vii, 1846, new series	74 21.6	74 21.6	1840.5
June,	1841	Major Graham, Trans. Amer. Phil. Soc., vol. ix, P. III, 1846	74 17.3	74 13.4	1841.6
July,	1841	Major Graham, Trans. Amer. Phil. Society—as above; Boston	74 09.4		
May,	1842	Prof. Locke, Trans., as above; Boston	74 05.7	74 14.5	1842.4
	1842	Prof. Locke, Trans., as above; Cambridge	74 14.9		
	1842	Capt. Lefroy, Silliman's Jour., new series, vol. iv, 1847	74 19.5		
	1842	Major Graham, Silliman's Jour., new series, vol. iv, 1847	74 17.8		
Dec.,	1844	Major Graham, Trans. Amer. Phil. Soc., vol. ix, P. III, 1846	74 18.2	74 18.2	1844.9
June,	1845	Prof. Locke, Smithsonian Contribution to Knowledge, vol. iii, 1852	74 19.4	74 19.4	1845.5
Sept.,	1846	U. S. Coast Survey (Assistant Fauntleroy, observer) at Dorchester Heights, South Boston	74 12.7	74 12.7	1846.7
Aug.,	1855	U. S. Coast Survey (Chas. A. Schott, observer) at South Boston Heights	74 29.1	74 29.1	1855.6

* Professor Loomis has some doubt about these observations. It is probable that either the needles were imperfect or that local attraction entered into the result.

The observations have been represented by the following formula:

$$I = 74^{\circ}.34 - 0.02840\,(t - 1840) + 0.002400\,(t - 1840)^2$$

the table shows the comparison of the observed and calculated inclinations.

t.	I observed.	I computed.	Δ
	°	°	°
1839.7	74.31	74.35	+ 0.04
1840.5	74.36	74.33	— 0.03
1841.6	74.22	74.30	+ 0.08
1842.4	74.24	74.28	+ 0.04
1844.9	74.30	74.26	— 0.04
1845.5	74.32	74.26	— 0.06
1846.7	74.21	74.26	+ 0.05
1855.6	74.48	74.48	0.00

The probable error of any single value is ± 1′.8.

Secular change of the magnetic dip at Providence, R. I.

				Mean dip.	Mean year.
			° ′		
Aug.,	1834	Prof. Bache, Sill's. Jour., vol. xliii., 1842	74 02.8	----------	1834.6
Sept.,	1839	Prof. Loomis, Trans. Amer. Phil. Soc., vol. vii., P. I., 1840	73 59.6	----------	1839.7
	1842	Capt. Lefroy, Sill's. Jour., new series, vol. iv., 1847	74 00.0	----------	1842.5
Aug.,	1855	United States Coast Survey, (Chas. A. Schott, obs'r,) Brown University	74 15.9	----------	1855.6

These observations can be represented by the formula:

$$I = 73^{\circ}.99 - 0.0040\,(t - 1840) + 0.00141\,(t - 1840)^2$$

Comparison of observed and computed values.

t	I observed.	I computed.	Δ
	°	°	°
1834. 6	74. 05	74. 06	+ 0. 01
1839. 7	73. 99	73. 99	0. 00
1842. 5	74. 00	73. 99	— 0. 01
1855. 6	74. 27	74. 27	0. 00

$$\varepsilon_0 = \pm 0'.7.$$

Secular variation of the magnetic dip at West Point and Cold Spring, N. Y.

				Mean dip.	Mean year.
			° ′	° ′	
April,	1833	Prof. Courtenay, Silliman's Journal, vol. xliii., 1842; also Trans. Amer. Phil. Soc., vol. v., 1835	73 25. 8	73 31. 5	1833. 9
June,	1834	Prof. Courtenay, Silliman's Journal, and Trans., as above	73 37. 2		
Sept.,	1839	Prof. Loomis, Trans. Amer. Phil. Soc., vol. vii., P. I., 1840	73 27. 4	73 27. 4	1839. 8
Aug.,	1840	Major Graham, Silliman's Jour., vol. iv., 1847	73 20. 1	73 20. 1	1840. 5
	1842	Capt. Lefroy, Silliman's Jour., vol. iv, 1847	73 30. 4	73 30. 4	1842. 5
Sept.,	1855	U. S. Coast Survey, (Chas. A. Schott, observer,) at Cold Spring	73 54. 8	73 54. 8	1855. 6

The above observations can be represented by the formula:

$$I = 73°.43 - 0.00165\ (t - 1840) + 0.002080\ (t - 1840)^2.$$

The agreement with the observed dip is as follows:

t	I observed.	I computed.	Δ
	°	°	°
1833. 9	73. 53	73. 52	— 0. 01
1839. 8	73. 46	73. 43	— 0. 03
1840. 5	73. 33	73. 43	+ 0. 10
1842. 5	73. 51	73. 44	— 0. 07
1855. 6	73. 91	73. 91	0. 00

The probable error of any single value is $\pm 3'.1$.

Secular change of the magnetic dip at New Haven, Conn.

				Mean dip.	Mean year.
			° ′	° ′	
Sept.,	1839	Prof. Loomis, Trans. Amer. Phil. Soc., vol. vii, 1840	73 26. 7	73 26. 7	1839. 7
April,	1842	Prof. Locke, Trans. Amer. Phil. Soc., vol. ix, 1846; also, Silliman's Jour., vol. iv, 1847	73 29. 8	73 28. 6	1842. 4
	1842	Capt. Lefroy, Silliman's Jour., vol. iv, 1847	73 27. 4		
Aug.,	1844	U. S. Coast Survey, (Prof. Renwick, observer;) Burial Grounds	73 27. 5	73 24. 2	1844. 5
Aug.,	1844	Same as above; Yale College	73 21. 0		
Sept. & Oct.,	1847	U. S. Coast Survey, (Asst. Fauntleroy, observer;) affected by local attraction	74 16. 6		
Aug.,	1848	U. S. Coast Survey, (Asst. Ruth, observer;) affected by local attraction. Both of these results are therefore excluded from the discussion	74 12. 6		
Aug.,	1848	U. S. Coast Survey, (observer as above;) Oyster Point	73 32. 9	73 32. 4	1848. 6
Aug.,	1848	Same as above; New Haven Pavillion	74 31. 9		
Aug.,	1855	U. S. Coast Survey, (Chas. A. Schott, observer;) Oyster Point	73 44. 4	73 44. 4	1855. 6

The above observations have been represented by the following formula:

$$I = 73°.42 + 0.0020\ (t - 1840) + 0.00117\ (t - 1840)^2.$$

Comparison of observed and computed dips.

t	I observed.	I computed.	Δ
	°	°	
1839.7	73.45	73.42	— 0.03
1842.4	73.44	73.43	— 0.01
1844.5	73.40	73.45	+ 0.05
1848.6	73.54	73.52	— 0.02
1855.6	73.74	73.73	— 0.01

$$\varepsilon_0 = \pm 2'.2.$$

Secular change of the magnetic dip at New York.

[Collection of observations arranged chronologically.]

				Mean dip.	Mean year.
			° ′	° ′	
Dec.,	1822	Col. Sabine, Trans. Amer. Phil. Soc., vol. v, P. II, 1835; near Columbia College	73 00.5		
	1823	Mean of Sabine's and Franklin's. Silliman's Jour., xxxix, 1840 (Prof. Loomis)	73 16.0	73 14.5	1823.9
March,	1825	Prof. Loomis, in Silliman's Jour., xliii, 1842	73 27.0		
April,	1831	Silliman's Jour., xxii, 1832. (Prof. Joslin)	73 00.0	73 0.00	1831.3
	1833	Prof. Loomis, in Silliman's Jour., xliii, 1842	72 49.3	73 01.6	1833.4
	1833	do do do	73 14.0		
Aug.,	1834	Pres. A. D. Bache and E. H. Courtenay, Trans. Amer. Phil. Soc., vol. v, P. II, 1835; Columbia College	72 51.7		
	1835	Mean by Capt. Back, Pres. Bache, and Prof. Loomis, Silliman's Jour., xxxix, 1840, (for 1835.3)	72 51.0	72 51.3	1835.0
Sept.,	1839	Prof. Loomis, Trans. Amer. Phil. Soc., vol. vii, P. I, 1840; Columbia College.	72 52.2	72 52.2	1839.7
April,	1841	Prof. Locke, Trans. Amer. Phil. Soc., vol. ix, P. III, 1846	72 41.0	72 41.0	1841.3
	1842	Capt. Lefroy, vol. iv, new series, Silliman's Jour., 1847; near N. Y.	72 39.5	72 38.3	1842.5
	1842	Prof. Locke, vol. iv, new series, Silliman's Jour., 1847; near N. Y.	72 37.2		
	1844	Maj. Graham, vol. iv, new series, Silliman's Jour., 1847; near N. Y.	72 28.9		
April,	1844	Prof. Locke, Trans. Amer. Phil. Soc., vol. ix, P. III, 1846	72 42.6		
May,	1844	do do do			
		The following observations were taken at Fort Lee to ascertain local attraction:		72 37.5	1844.4
		72° 28′, 47′, 51′, 38′, 39′ mean 40.6	72 40.6		
Aug.,	1844	U. S. Coast Survey, (Prof. Renwick, observer)	72 37.8		
	1845	Letter of Prof. Hansteen, dated Christiania, October 15, 1854, to the Norwegian and Swedish ministers at Washington	72 40.6	72 40.6	1845.5
April,	1846	U. S. Coast Survey (Prof. Locke, observer) at Station Bloomingdale	72 39.0	72 39.2	1846.6
Nov.,	1846	Letter of Prof. Hansteen of October 15, 1854. Observer, Chief of the Corvette Nordstiernen Gambey Incli'n	72 39.3		
Aug.,	1855	U. S. Coast Survey (Chas. A. Schott, observer) at Governor's island	72 45.9		
Aug.,	1855	Same as above; observed at Bedloe's island	72 59.3	72 49.9	1855.6
Aug.,	1855	Same as above; observed at Receiving Reservoir, N. Y.	72 44.4		

These 11 values are represented by the formula:

$$I = 72^\circ.69 - 0.00491\,(t - 1845) + 0.001141\,(t - 1845)^2, \text{ as follows:}$$

t	I observed.	I computed.	Δ
	°	°	
1823.9	73.24	73.31	+ 0.09
1831.3	73.00	72.98	— 0.02
1833.4	73.03	72.91	— 0.12
1835.0	72.86	72.86	0.00
1839.7	72.87	72.75	— 0.12
1841.3	72.68	72.73	+ 0.05
1842.5	72.64	72.71	+ 0.07
1844.4	72.62	72.70	+ 0.08
1845.5	72.68	72.69	+ 0.01
1846.6	72.65	72.69	+ 0.04
1855.6	72.83	72.77	— 0.06

The probable error of any single value is $\pm\,3'.3$.

The above formula when transformed for the epoch 1840 becomes:
$I = (i_0 - 5\,y + 25\,z) + (y - 10\,z)\,(t - 1840) + z\,(t - 1840)^2$ or numerically:
$I = 72^\circ.75 - 0.01632\,(t - 1840) + 0.001141\,(t - 1840).^2$

Secular change of the magnetic dip at Philadelphia, Pennsylvania.

			° ′	Mean dip. ° ′	Mean year.
July,	1834	Pres. A. D. Bache and E. H. Courtenay, Trans. Amer. Phil. Soc., vol. v, 1835	72 00.2	72 00.2	1834.5
	1838	Pres. A. D. Bache, Silliman's Jour., vol. xxxix, 1840. The result is probably affected by local attraction, or the small dip is due to an imperfect needle	71 43.9	----------	----------
Sept.,	1839	Prof. Loomis, Trans. Amer. Phil. Soc., vol. vii, 1840; near Pres. Bache's house	72 07.1	72 00.2	1840.2
Sept.,	1840	Pres. Bache, Silliman's Jour., vol. xlii, 1842	71 53.3		
April,	1841	Prof. Bache, Trans. Amer. Phil. Soc., vol. viii, 1843; Girard College	71 58.2		
June,	1841	Maj. Graham, Trans. Phil. Soc., vol. ix, 1846; Girard College	71 54.5	71 58.1	1841.3
March,	1841	Trans. Amer. Phil. Soc., vol. ix, 1846; mean of two results	72 00.7		
April,	1841	Trans. Amer. Phil. Soc., vol. ix, 1846; mean of two results	71 59.0		
	1842	Prof. Locke, Silliman's Jour., vol. iv, 1847	72 00.1		
	1842	Capt. Lefroy, Silliman's Jour., vol. iv, 1847	71 59.0		
May,	1842	Trans. Amer. Phil. Soc., vol. ix, 1846	72 01.0		
	1842	Prof. A. D. Bache. Observations at magnetic observatory, Girard College, 1840-'45. (Washington, 1847, 4 vols.) Mean of monthly observations from January to December	72 00.1	72 00.0	1842.5
	1843	Mean of monthly observations from April to December	71 57.5	71 57.5	1843.6
	1844	Mean of monthly observations from January to July	71 57.6		
April,	1844	Prof. Locke, Trans. Amer. Phil. Soc., vol. ix, 1846	71 59.3		
May,	1844	Trans., as above. Rittenhouse square	72 09.2	72 02.0	1844.4
	1844	Maj. Graham, Silliman's Jour., vol. iv, 1847	72 01.8		
May,	1846	United States coast survey, (J. Locke, observer,) Girard College	72 01.0	72 01.0	1846.4
Sept.,	1855	United States Coast Survey, (Chas. A. Schott, observer,) Girard College	72 17.7	72 17.7	1855.7

The above values can be represented by the formula $I = 71^\circ.99 + 0.0010\,(t - 1840) + 0.00124\,(t - 1840)^2$.

The positive sign of y probably arises from too small a dip in 1834, which also causes the minimum to shift to an earlier date than the other stations indicate.

The formula represents the observations as follows:

t	I observed.	I computed.	Δ
	°	°	°
1834.5	72.00	72.02	+ 0.02
1840.2	72.00	71.99	— 0.01
1841.3	71.97	71.99	+ 0.02
1842.5	72.00	72.00	0.00
1843.6	71.96	72.01	+ 0.05
1844.4	72.03	72.02	— 0.01
1846.4	72.02	72.05	+ 0.03
1855.7	72.30	72.31	+ 0.01

The probable error of any single value is $\pm\ 1'.0$.

If we consider the important series of dips observed at the Girard Observatory by itself, we find the secular change between 1842 and 1844 much masked by the annual inequality and other irregularities, as will be seen from the table below, in which each monthly result is the mean of four complete observations.

	1842.		1843.		1844.	
	° ′	° ′	° ′	° ′	° ′	° ′
January	71 57.5		------		71 56.2	
February	58.4	71 58.4	------		59.4	71 58.0
March	59.4		------		58.5	
April	58.9		71 54.9		56.0	
May	61.1	60.2	63.2	71 58.5	57.1	57.3
June	60.7		57.7		57.3	
July	57.1		57.7		71 58.8	
August	60.2	59.5	57.8	57.8	------	
September	61.2		57.9		------	
October	61.1		54.8		------	
November	64.2	62.2	56.4	56.3	------	
December	61.5		57.7		------	
Mean	71 60.1		71 57.5		71 57.6	

The quarterly means probably indicate the minimum about autumn, 1843; in the recapitulation, however, I have preferred to give the result derived from the discussion of all observations.

Secular change of the magnetic dip at Washington, D. C.

[Collection of observations arranged chronologically.]

			Mean dip.	Mean year.
		° ′	° ′	
1838	Lieut. Wilkes, Loomis in Sill's Jour., vol. xxxix, 1840	71 13.0	71 17.5	1839.2
Sept., 1839	Prof. Loomis, Trans. Amer. Phil. Soc., vol. vii, 1840. Yard in front of the Capitol	71 21.4		
1840–'41	Lieut. J. M. Gilliss, Sill's Jour., vol. i, 1846; also Senate doc. 2d session 28th Cong., 1844-'45. On Capitol Hill. Mean dip for 1840–'41	71 20.2	71 18.3	1841.0
June, 1841	Maj. Graham, Trans. Amer. Phil. Soc., vol. vii, 1st series, 1844. In centre of public garden east of the Capitol	71 15.7		
1841–'42	Lieut. J. M. Gilliss, as above	71 18.0		
June & Aug., 1841.	Maj. Graham, and Nicollet, Trans. Amer. Phil. Soc., vol. viii, p. 3, 1843, 4th series, by Loomis. Eastern garden of Capitol, June, 1841, 71° 15′.4; in July, 1841, 71° 15′.0; in July, 1841, 71° 13′.8; in August, 1841, 300 yards N.N.W. of preceding station, 71° 15′.0 Mean of all	71 15.5		
1842	Maj. Graham, Sill's Jour., vol. iv, 1847	71 13.1	71 13.5	1842.5
1842	Capt. Lefroy, Sill's Jour., vol. iv., 1847	71 13.8		
April, 1844	Prof. Locke, Trans. Amer. Phil. Soc., 1844, 7th series. At magnetic observatory, 71° 39′ 20″; at old depot, near Georgetown, 34′ 48″; west side of Capitol, 13′ 23″; east side of Capitol, 13′ 27″; near Patent Office, 14′ 58″; near War Office, 20′ 30″. Mean of all, including 71° 19′ in Georgetown	71 22.2	71 16.4	1844.4
July, 1844	Maj. Graham, Trans. Amer. Phil. Soc., 1844. Same place as in 1841	71 10.6		
Jan. & Feb., 1845.	U. S. Coast Survey, (Capt. Lee, observer,) near Coast Survey office, Capitol Hill	71 35.3		
May, 1845	Same as above	71 32.5		
1845	Same as above. Omitted in discussion as anomalous	71 58.9		
June, 1851	U. S. Coast Survey, (Assistant Dean, observer,) at Causten, near Georgetown	71 18.9	71 18.9	1851.5
May, 1852	U. S. Coast Survey, (Assistant Hilgard, observer,) between Capitol and City Hall	71 23.1	71 23.1	1852.4
July, 1855	U. S. Coast Survey, (Charles A. Schott, observer,) at magnetic observatory, Smithsonian grounds	71 27.0	71 28.3	1855.7
Sept., 1855	Same as above, at Causten, near Georgetown	71 29.5		

The following formula represents these observations:

$$I = 71^\circ.29 - 0.01496\,(t - 1840) + 0.001728\,(t - 1840)^2$$

with the differences:

t.	I observed.	I computed.	Δ
	°	°	°
1839.2	71.29	71.30	+ 0.01
1841.0	71.30	71.27	— 0.03
1842.5	71.22	71.26	+ 0.04
1844.4	71.27	71.25	— 0.02
1851.5	71.32	71.34	+ 0.02
1852.4	71.39	71.37	— 0.02
1855.7	71.47	71.48	+ 0.01

The probable error of any single result is $\pm$ 1'.2.

Secular change of the magnetic dip at Baltimore, Md.

				Mean dip.	Mean year.
			° '	° '	
July,	1834	Prof. Bache and Prof. Courtenay, Trans. Amer. Phil. Soc., vol. v., p. 2, 1835. Holliday street. This is undoubtedly affected by local attraction	70 58.6		
Sept.,	1839	Prof. Loomis, Trans. Amer. Phil. Soc., vol. ix, 1846, P. 3	71 50.3	71 50.3	1839.7
Aug.,	1840	Prof. Bache, Trans., as above. Howard's wood	71 34.4	71 34.4	1840.6
April,	1841	Prof. Locke, Trans., as above. Howard's wood	71 34.1		
April,	1841	Nicollet, Trans., as above. Howard's wood	71 34.1		
April,	1841	Trans. Amer. Phil. Soc., vol. viii, P. 3, 1843. Near Washington monument	71 34.9		
April,	1841	Trans., as above. St. Mary's garden	71 38.6		
June,	1841	Maj. Graham, Trans. Amer. Phil. Soc., vol. ix, 1846, P. 3	71 31.2	71 37.0	1841.6
	1841	Prof. Locke, Silliman's Jour., vol. iv, 1847	71 36.8		
June,	1841	Maj. Graham and Nicollet, Trans. Amer. Phil. Soc., vol. ix, P. 3, 1846.	71 43.4		
Aug.,	1841	Trans., vol. viii, P. 3, 1843. Prof. Loomis. St. Mary's	71 39.8		
Aug.,	1841	Trans., as above. Prof. Loomis. Washington monument	71 35.9		
Nov.,	1841	Trans., as above	71 40.8		
	1842	Maj. Graham, Silliman's Jour., vol. iv, 1847	71 39.7	71 40.5	1842.5
	1842	Capt. Lefroy, Silliman's Jour., vol. iv, 1847	71 41.4		
July,	1844	Trans. Amer. Phil. Soc., vol. ix, 1846	71 32.5	71 36.0	1844.5
July,	1844	Trans. Amer. Phil. Soc., vol. ix, 1846. St. Mary's	71 39.5		
June,	1845	U. S. Coast Survey, (Capt. T. J. Lee, observer,) at Rosan. This place, however, is too far off	72 06.6		

For want of an observation at the present time, the formula expressing the variation in the dip can only be approximate; the observations are well represented by

$$I = 71^\circ.72 - 0.0357\,(t - 1840) + 0.00104\,(t - 1840)^2$$

which agrees very well, in regard to the curvature (z,) with the results at other stations.

RECAPITULATION OF RESULTS.

TABLE No. 1.

Geographical position of stations, and number of observations for dip at each.

No.	Stations.	Latitude.		Longitude.		No. of observ'ns.
		°	′	°	′	
1	Toronto, Canada	43	33	79	20	15
2	Albany, (and Greenbush,)New York	42	37	73	44	9
3	Cambridge, (and Boston,) Massachusetts	42	22	71	07	17
4	Providence, Rhode Island	41	50	71	24	4
5	West Point, (and Cold Spring,) New York	41	25	73	57	6
6	New Haven, Connecticut	41	17	72	55	10
7	New York, N. Y.	40	43	74	00	22
8	Philadelphia, Pennsylvania	39	58	75	10	45
9	Washington, (and Georgetown,) District of Columbia	38	53	77	01	17
10	Baltimore, Maryland	39	18	76	37	16

TABLE No. 2.

Formula expressing the inclination at the several stations, arranged in order of their magnetic latitude.

Toronto	$I = 75°.29 - 0.0144\,(t-1840) + 0.00164\,(t-1840)^2$
Albany	$I = 74.70 - 0.0086$ " $+ 0.00257$ "
Cambridge	$I = 74.34 - 0.0284$ " $+ 0.00240$ "
Providence	$I = 73.99 - 0.0040$ " $+ 0.00141$ "
West Point	$I = 73.43 - 0.0016$ " $+ 0.00208$ "
New Haven	$I = 73.42 + 0.0020$ " $+ 0.00117$ "
New York	$I = 72.75 - 0.0163$ " $+ 0.00114$ "
Philadelphia	$I = 71.99 + 0.0010$ " $+ 0.00124$ "
Washington	$I = 71.29 - 0.0150$ " $+ 0.00173$ "

The agreement of the values for y and z must be considered as very satisfactory. The shifting of the epoch t_0 of a few years would give an equal sign to y for all stations, but, by so doing, nothing is gained. The coefficients z, expressing the curvature, are still more accordant than the y's. For the graphical representation of observations and results see diagram No. 63.

TABLE No. 3.

Showing the probable error ε_0 of any single determination for dip, (or in many cases of the means of several observations at the same time,) the epoch τ of the minimum dip, and the annual variation v in the current year.

Stations.	ε_0	τ	v 1856.
	′		′
Toronto	± 0.6	1844.4	+ 2.1
Albany	0.9	1841.7	+ 4.3
Cambridge	1.8	1845.9	+ 2.9
Providence	0.7	1841.4	+ 2.9
West Point	2.4	1840.4	+ 3.9
New Haven	2.2	1839.2	+ 2.3
New York	3.3	1847.1	+ 1.2
Philadelphia	1.0	1839.6	+ 2.2
Washington	1.2	1844.3	+ 2.4
Mean	± 1.6	1842.7±0.7	+ 2.7

Professor Hansteen, in his paper in the Ast. Nach. alluded to before, obtained for New York a result contradictory to the above well-established one, and supposed the dip to attain a maximum value in 1822.3. This is due to the small number and uncertainty of the observations used. The recent observations have been furnished to him at his request, and he will probably see cause to modify his former conclusions on this point.

We see thus that the inclination became stationary 1842.7—1797.2, or 45½ years after the declination was in a similar condition.

In the northeastern States the inclination reached a minimum about the middle of the year 1843, and from a previous decrease has been increasing since that time with a gradually accelerated rate.

The formulæ deduced apply with certainty for ten or fifteen years before and after the year 1843, and, in the absence of other information, may be extended as far back as the commencement of the present century.

I append a few remarks in reference to the secular change in the western part of this continent. While at St. Louis and other places in the western States the dip was decreasing since 1819 until about 1842, we find the same movement to have taken place on the Western Coast; and from the scanty material available in that region, we have sufficient proof of the fact, that, since the close of the past century, the dip was decreasing at an average rate of about 2′ a year, and after having become stationary nearly about the same time as on the Atlantic Coast, is now on the increase. Thus, at San Diego, the minimum took place about 1844, and even as high north as Sitka this epoch appears to have obtained. Professor Hansteen, in No. 947, Ast. Nach., calculates for that place—

$I = 75^\circ.84 + 0.0084\,(t - 1840) + 0.00068\,(t - 1840)^2$ and consequently $\tau = 1833.8 \pm 6.4$ years.

Thus it appears, with great probability, that over the northern part of the United States, from ocean to ocean, the secular change of the inclination has been following a uniform law, reversing its direction about the same period.

In regard to the southern States there is not a sufficient number of observations to permit a conjecture as to the secular variation of the dipping needle.

I remain, sir, yours, very respectfully,

CHAS. A. SCHOTT.

Professor A. D. Bache,
Superintendent U. S. Coast Survey.

APPENDIX No. 33.

An attempt to determine the secular variation of the magnetic inclination on the Western Coast of the United States, by Chas. A. Schott, in charge of Computing Division, Coast Survey office.

COMPUTING DIVISION, COAST SURVEY OFFICE, *May* 7, 1856.

DEAR SIR: The fourth contribution to the discussion of terrestrial magnetism, viz: "An attempt to determine the secular variation of the magnetic inclination on the Western Coast of the United States," is herewith respectfully submitted.

While the few observations for magnetic declination on our Pacific Coast scarcely afford the means of deducing the law of its change, in direction and quantity, we are left in still greater obscurity in reference to the secular change of the dip. The table of declinations comprises about 55 observations, but the following collection of determinations for dip includes but 24, and what is particularly desirable in the latter, recent observations, are wanting almost entirely. The operations of the Coast Survey have just commenced and furnish but four determinations, and these are the only ones of a recent date which I was able to bring to bear on the subject. Under these circumstances it seems premature to enter into any discussion for secular change; but in view of some light which the material collected will afford, and the advantage of knowing something about its probable direction and amount, the scanty material and some deductions are herewith subjoined.

As a beginning, for a future discussion, the table will not be without its value, and will also prove advantageous, as well as the former table of declinations on the same coast, in pointing out those places where new observations are most desirable and effective. As before, in the discussion of the secular change of the dip on the Eastern Coast, the dip of the north end of the needle is considered as positive.

Table of magnetic inclinations observed on the Western Coast of the United States from the earliest times to the present, arranged in the order of the geographical latitude of the stations.

No. of stat'n.	Name of place.	Latitude.	Longitude.	Year.	Month.	N. Incl'n.	Observer.	Authority or reference.	Remarks.
		° '	° '			° '			
1	San Diego	34 42	116 53	1793	Nov.&Dec.	59 13	Vancouver	Hansteen's Mag. der Erde, 1819	The latitude is erroneously given 34°. Observation taken probably on shore.
	do	32 41	117 13	1839		57 06. 1	Sir E. Belcher	Phil. Trans. Roy. Soc., 1841	
	do	32 42	117 13. 4	1853	September.	57 38. 6	W. P. Trowbridge	U. S. Coast Survey	At the plaza, near custom-house.
2	San Pedro	33 43	118 15	1839		58 21. 4	Belcher	Phil. Trans. Roy. Soc., 1841	
	do	33 46	118 16. 1	1853	November.	59 32. 6	W. P. Trowbridge	U. S. Coast Survey	Three miles north of San Pedro anchorage.
3	Santa Barbara	34 24	119 41	1839		58 54. 1	Belcher	Phil. Trans. Roy. Soc., 1841	
4	San Luis Obispo	35 10. 6	120 43. 5	1854	January	59 42. 2	W. P. Trowbridge	U. S. Coast Survey	
5	Monterey			1790	September.	60 56. 2	Don A. Malaspina	Berl. Ast. Jah., vol 53, for 1828	On land.
	do	36 36	121 34	1792	December	63 00. 5	Vancouver	Hansteen's Mag. der Erde, 1819	
	do	36 36	121 51	1794	November.	63 00	do	do do	
	do	36 35	122 00	1831	January	62 07. 5	Douglass	Report Brit. Ass'n, vol. 6, 1838	
	do	36 36	121 53	1839		61 03. 6	Belcher	Phil. Trans. Roy. Soc., 1841	
	do			1843	September	61 58. 9	Th. Perry	Sill's Jour. Sci. and Arts, v. xlvii.	
6	San Francisco	37 48	122 25	1831	February	62 58	Douglass	Report Brit. Ass'n, vol. 6, 1838	
	do	37 48	122 23	1837		61 53. 8	Belcher	Phil. Trans. Roy. Soc., 1841	
	do	37 48	122 23	1839		62 05. 8	do	do do	
7	Port Bodega	38 18	123 02	1839		62 53. 4	do	Phil. Trans. Roy. Soc., 1841	
8	Fort Vancouver	45 37	122 36	1830	November.	69 39. 7	Douglass	Rep. of Brit. Ass'n Adv. of Sci., vol. 6, 1838	On Columbia river.
	do	45 37	122 36	1839		69 22. 2	Belcher	Phil. Trans. Roy. Soc., 1841	do
9	Point George	46 11	123 40	1830	December	69 16. 8	Douglass	Rep. Brit. Ass'n, vol. 6, 1838	Near Columbia river.
10	Cape Disappointment.	46 16	123 56	1830	Septem. & December.	69 30. 3	do	do do	Mouth of Columbia river.
	do	46 17	124 02	1839		69 26. 9	Belcher	Ph. Trans. Roy. Soc., 1841	On Baker's bay.
11	Neé-ah bay	48 22. 0	124 36. 6	1855	August 21	71 16. 2	W. P. Trowbridge	U. S. Coast Survey	Near Waddah island.
12	Port Discovery	48 02	122 38	1792	Apr.&May	74 30	Vancouver	Hansteen's Mag. der Erde, 1819	The longitude is about ½° too small. Observ'n probably taken on shore.

Deductions from the foregoing table.

1. *San Diego.*—At this place the three observations, viz:

In 1793.9	dip	59°.22
1839.5		57.10
1853.7		57.64 are represented by the formula:

$$I = + 57^\circ.11 + 0.0194\ (t - 1840) + 0.00141\ (t - 1840)^2,$$

which gives a minimum for 1833.1, and an annual increase for 1850 of + 2′.8. This accords well, as has been before remarked, with the variation deduced for the northeastern States, where the average minimum was found to have taken place in 1842.7, and the average increase for 1850 was + 1′.2. The formula is further supported by the observations collected at Sitka, which, although comparatively in a high northern latitude, show a correspondence with the change in more southern latitudes (magnetic or geographical.) Professor Hansteen has discussed seven observations at this place; see "Astronomische Nachrichten, No. 947," and "Der magnetiske Inclinations Forandring i den nordlige tempererte zone; Kjobenhaven, 1855, p. 42." He finds $I = 75^\circ.84 + 0.0084\ (t - 1840) + 0.00068\ (t - 1840)^2$ when expressed in decimals of degrees and referred to 1840. The minimum took place in 1833.8 ± 6.4 years. The probable error of a single observation is ± 2′.6. The increase for 1850 becomes + 1′.3.

2. *San Pedro.*—The two observations of 1839 and 1853 indicate a mean annual increase of 5′.1, which is undoubtedly too great and is probably due to local attraction; it may also indicate a constant error in the dipping needle used by Sir E. Belcher; (see his observations at Monterey.)

5. *Monterey.*—The observations at this place are too discordant to admit of a discussion of the secular change, even after using a mean value for the first three observations. The observations of 1790 and 1837 are undoubtedly too small; a new observation, however, will probably afford the means of deducing a satisfactory result.

6. *San Francisco.*—The dip from 1831 to 1838 has been decreasing, if Douglas' observation in 1831 is correct; the observations of Belcher in 1837 and 1839 show again an increase.

8. *Fort Vancouver.*—The dip between 1830 and 1839 has been decreasing about 2′ a year.

10. *Cape Disappointment.*—The dip between 1830 and 1839 has been slowly decreasing about 0′.4 a year.

Although the change indicated by the above stations is far from showing any satisfactory agreement, yet the results have at least a general tendency not contradictory to what we have found for San Diego and Sitka. This more than indirect support of the rest of the stations, thus makes it highly probable that since about 1836 the dip on the Western Coast has been on the increase, and is still increasing at present with a rate of perhaps not less than 2′ a year.

A decrease probably took place since the commencement of the present century till about 1836. New observations will undoubtedly enable us to fix this epoch with some certainty, but for the present nothing more definite can be inferred. Should the above be confirmed hereafter, the direction of the dipping needle in its secular change does not present that complex motion which was noticed in the declination changes within the limits of the United States.

The following few remarks will not be found inappropriate in this place:

At Nootka, on Vancouver's island, in lat. 49° 36′ N., long. 126° 37′ W., the observations do not cover a sufficient interval of time and appear too discordant to be available at present. We have for that place—

Cook	in 1778.3	dip	72°.50
Malaspina	1790.6		70.34
Vancouver	1792.6		73.93
Vancouver	1794.0		73.93

Malaspina's needle gives undoubtedly results too small, for which compare the observations at Monterey.

Turning south, the dip at the City of Mexico between 1778 and 1799 seems to have been on the increase.

For the tracing of the isoclinal lines in the Pacific ocean, off the Western Coast, some of the observations of Captain Lütke, in 1827, (Report of the British Association for Adv. of Sci., vol. 6, 1838,) and particularly Mr. Erman's observations at sea in 1837, (7th Report of the Brit. Assoc.,) will prove of great value, as will also Sir E. Belcher's determination on the peninsula of California and Mexico.

As a connecting link with the Atlantic coast, we find at St. Louis, Mo., from 1819, the dip to be decreasing till 1841, when the annual change became very small, and at Cincinnati, Ohio, the minimum occurred in 1842, the dipping needle at that period being also stationary at Pittsburg, Pa.

In regard to the secular change of the magnetic dip, it would be most desirable to have new observations at the stations Monterey, San Francisco, and Cape Disappointment.

Respectfully submitted by CHAS. A. SCHOTT.

Captain W. R. PALMER, *Top'l Eng'rs, Ass't in charge C. S. Office.*

APPENDIX No. 34.

Notes on the progress made in the Coast Survey, in prediction tables for the tides of the United States coast, by A. D. Bache, Superintendent United Coast Survey, &c.

[Communicated to the American Association for the Advancement of Science, by authority of the Treasury Department.]

As soon as tidal observations had accumulated sufficiently to make the task a profitable one, I caused them to be treated, under my immediate direction, by the methods in most general acceptance. The observations at Old Point Comfort, Virginia, were among the earliest used for this purpose; and the labors of Commander Charles H. Davis, U. S. N., then an assistant in the Coast Survey, were directed to their reduction, chiefly by the graphical methods pointed out by Mr. Whewell. This work was subsequently continued by Lubbock's method, by Mr. Henry Mitchell; and next the tides of Boston harbor were taken up as affording certain advantages in the observations themselves, which could not be claimed for those of Old Point.

The system of Mr. Lubbock is founded on the equilibrium theory, and in it the inequalities are sought by arranging the elements of the moon's and sun's motions upon which they depend. Having obtained the coefficient of the half monthly inequality of the semi-diurnal tide at Boston, from seven years' observations, through the labors of the tidal division, and approximate corrections for the parallax and declination, I was much disappointed in attempting the verification by applying them to individual tides for a year, during which we had observations. There was a general agreement on the average, but discrepancies in the single cases, which were quite unsatisfactory. Nor were these discrepancies without law, as representing their residuals by curves did not fail to show. By introducing corrections for declination and parallax of the moon increasing and decreasing, we reduced these discrepancies, but still the results were not sufficient approximations. With the numerical reductions of the observations before referred to was commenced, in 1853, under my immediate direction, by Mr. L. W. Meech, a study of the theory of the tides, directed chiefly to the works of Bernouilli, La Place, Airy, Lubbock, and Whewell. The immediate object which I had in view was the application of the wave theory to the discussion of our observations. I thought that the mind of an expert mathematician, directed entirely to the theoretical portions of this work, with directions by a physicist, and full opportunities of verifying results by extended series of observations, the computations of which should be made by others in any desired form, would give probably the best results in this combined physical and mathematical investigation.

The general form of the different functions expressing the tidal inequalities is the same in the different theories, and may be said on the average to be satisfactory as to the laws of change which these inequalities present. Whether we adopt, with La Place, the idea that periodical forces produce periodical effects; or with Airy, that the tidal wave arrives by two or more canals; or with Bernouilli and Lubbock, the results of an equilibrium spheroid; or with Whewell, make a series of inequalities, semi-menstrual, parallax, and declination, with different epochs, we arrive at the same general results, that the heights and times of high water may be represented by certain functions, with indeterminate coefficients, in the form of which the theories in a general way agree. By forming equations from the observations, and obtaining the numerical values of the coefficients, by the method used so commonly in astronomical computations, the result is accomplished.

A general consideration of the co-ordinates in space of the moon and sun, without any special theory, would lead to the same results, representing the luni-tidal interval by series of sines and co-sines, with indeterminate coefficients.

Calling I the luni-tidal interval from observation, λ the mean luni-tidal interval, H the clock time of observation, $l't$ the moon's longitude, P' the moon's parallax, $\delta P'$ the hourly variation of the moon's parallax, we have for the formula representing the correction for half monthly inequality, $s \sin 2H + s_1 \cos 2H$; for the moon's parallax correction, $p(P'-57') + p_2(P'-57') \sin 2H + p_3(P'-57') \cos 2H$; for the correction for hourly difference of the moon's parallax, $p_1(\delta P') + p_4(\delta P') \sin 2H + p_5(\delta P') \cos 2H$; and for the moon's declination corrections, including the rate of change, $d \sin 2l't + d_1 \cos 2l't + q_1 \sin 2l't \sin 2H + q_2 \sin 2l't \cos 2H + q_3 \cos 2l't \sin 2H + q_4 \cos 2l't \cos 2H$. There are corresponding terms for the inequalities produced by the sun's action. The whole formula takes the form:

$I = \lambda + s \sin 2H + s_1 \cos 2H$ mean interval and half monthly inequality correction.
$p(P'-57') + p_2(P-57') \sin 2H + p_3(P'-57') \cos 2H$ moon's parallax correction.
$p_1(\delta P') + p_4(\delta P') \sin 2H + P_5(\delta P') \cos 2H$ hourly difference of moon's parallax correction.

$$\left.\begin{array}{l} d \sin 2l't + q_1 \sin 2l't \sin 2H + q_2 \sin 2l't \cos 2H \\ d_1 \cos 2l't + q_3 \cos 2l't \sin 2H + q_4 \cos 2l't \cos 2H \end{array}\right\} \text{Moon's declination corrections.}$$

$$\left.\begin{array}{l} + t_1 \sin lt \sin 2H + t_2 \sin lt \cos 2H \\ + t_3 \cos lt \sin 2H + t_4 \cos lt \cos 2H \end{array}\right\} \text{Sun's parallax corrections.}$$

$$\left.\begin{array}{l} + Q_1 \sin 2lt \sin 2H + Q_2 \sin 2lt \cos 2H \\ + Q_3 \cos 2lt \sin 2H + Q_4 \cos 2lt \cos 2H \end{array}\right\} \text{Sun's declination corrections.}$$

The grouping of the observations of one year at Boston, to apply this method, the formation of the equations and their solution by the method of indirect elimination, has been the work of Mr. R. S. Avery, who has labored most assiduously and successfully, ingeniously checking his work, where the system of checks could be applied, at every step. He has determined the values of λ and of the coefficients for Boston, as follows:

$$\begin{array}{l} \lambda = +38.47,\ d = -3.17,\ d_1 = -35.62,\ p = -0.93,\ p_1 = -1.56 \\ s = -19.49,\ s_1 = +11.97,\ p_2 = +1.31,\ p_3 = -1.21,\ p_4 = +0.23 \\ p_5 = +0.60,\ q_1 = -7.17,\ q_2 = +1.81,\ q_3 = +2.91,\ q_4 = -1.99 \\ t_1 = +5.14,\ t_2 = +2\ 26,\ t_3 = -0.76,\ t_4 = -1.37 \\ Q_1 = -21.25,\ Q_2 = +28.39,\ Q_3 = +27.10,\ Q_4 = +23.13 \end{array}$$

There are propositions for facilitating this work, growing out of the experience acquired in the computations, but requiring more examination than they have yet received before pronouncing upon them. It is possible that, by applying Lubbock's method of averages to some of the terms, approximate values may be found more readily than by the method we have employed. Two additional terms for the sun's declination, $D \sin 2lt$, and $D_1 \cos 2lt$, will be introduced.

I present to the Association the tables computed by Mr. Avery for applying this method to the prediction of the tides at Boston harbor.

In order to test the coefficients, computations were made for different parts of the months o the year 1853, for which we have observations. Transit C was used as the transit of reference. The differences between the predicted and observed results are shown in the annexed table—the first column of which contains the dates, the second the computed, the third the observed, and the fourth the observed less the computed results.

From the table it appears that in twenty pairs of tides, the morning and afternoon results being grouped in the fifth column to get rid of the diurnal inequality, there are two differences of less than 2^m, thirteen of more than 2^m and less than 4^m, three of more than 4^m and less than 10^m, two of more than 10^m. The probable error of the prediction of a single pair of tides is $4^m.12$.

These laborious researches are still in progress, but I have thought that the results already obtained required a notice of them, and a recognition of the labors of Messrs. Meech and Avery.

Comparison of observed and predicted times of high water, Boston, Massachusetts.

Date.		Time of high water. Predicted.	Time of high water. Observed.	Diff. obs'd pairs.	Mean of pairs.
1853.		*h. m.*	*h. m.*	*m.*	*m.*
March	21	8 4.7	8 3	— 1.7	
	21	20 32.9	20 32	— 0.9	— 1.3
	25	11 28.0	11 21	— 7.0	
	25	23 49.8	23 48	— 1.8	— 4.4
	29	2 21.7	2 20	— 1.7	
	29	14 45.3	14 42	— 3.3	— 2.5
April	2	6 16.9	6 21	4.1	
	2	18 51.5	18 59	7.5	5.8
	6	10 19.8	10 18	— 1.8	
	6	22 40.2	22 36	— 4.2	— 3.0
June	21	11 18.4	11 18	— 0.4	
	21	23 44.7	23 49	4.3	2.0
	25	2 34.5	2 39	4.5	
	25	15 2.3	15 3	0.7	2.6
	29	5 57.7	6 7	9.3	
	29	18 24.3	18 37	12.7	11.0
July	3	9 27.4	9 31	3.6	
	3	21 52.2	21 53	0.8	2.2
	7	0 0.1	0 3	2.9	
	7	12 10.3	12 12	1.7	2.3
September	24	3 59.4	4 7	7.6	
	24	16 24.8	16 24	— 0.8	3.4
	28	7 39.7	7 44	4.3	
	28	20 11.6	20 15	3.4	3.9
October	2	11 6.1	11 4	— 2.1	
	2	23 31.1	23 30	— 1.1	— 1.6
	6	1 44.7	1 40	— 4.7	
	6	14 7.7	14 7	— 0.7	— 2.7
	10	5 24.5	5 19	— 5.5	
	10	17 57.8	17 58	0.2	— 2.7
December	21	3 7.2	3 9	1.8	
	21	15 28.4	15 30	1.6	1.7
	25	6 32.6	6 31	— 1.6	
	25	19 0.7	18 52	— 8.7	— 5.2
	29	10 22.4	10 26	3.6	
	29	22 53.3	22 42	—11.3	— 3.9
January	2	1 29.4	1 2	—27.4	
	2	13 54.0	13 41	—13.0	—20.2
	6	4 45.8	4 53	7.2	
	6	17 33.9	17 30	— 3.9	1.7

Final mean 0.5
Probable error, minutes 4.12
Number of difference less than 2 minutes............ = 2
Number of differences more than 2 min., and less than 4 = 13
" " 4 " 10 = 3
" " 10 .... = 2

APPENDIX No. 35.

Approximate co-tidal lines of diurnal and semi-diurnal tides of the coast of the United States on the Gulf of Mexico, by A. D. Bache, Superintendent United States Coast Survey.

[Communicated by authority of the Treasury Department to the American Association for the Advancement of Science.]

At successive meetings of the American Association, I have presented approximate co-tidal lines for the Atlantic and Pacific coasts of the United States, drawn from the tidal observations of the Coast Survey. I now present similar lines for our coast on the Gulf of Mexico.

The problem is a very different one from either of the others referred to. The tides on the Atlantic coast are of the regular semi-diurnal class, and easily discussed by the forms already elaborately prepared by Lubbock and Whewell. The diurnal inequality is not large; indeed, though easily recognized at particular periods, and then quite characteristic, in general it is difficult to trace, and often irregular in magnitude, and even in sign. Those of the Pacific coast are remarkably regular in the semi-diurnal and diurnal waves, and both rise to such heights as to make observation easy. On the Gulf coast, on the contrary, the tides are small, and therefore easily influenced by extraneous circumstances; and, as a rule, on more than two-thirds of the coast, the semi-diurnal tides are very small, and, in fact, are masked by the diurnal tides. The comparatively imperfect discussion which has been made of these tides requires many steps in the discussion to be supplied, and sometimes leaves us in doubt as to the exact interpretation of the results.

By way of preparing for the present discussion, and to avoid running into too great length at this time, I gave, at the last meeting of the Association, an account of the tidal observations made on our Gulf coast, and showed the type curves (sketch No. 38) for the different stations from Cape Florida to the Rio Grande.* I also explained the method of decomposition of the curves of observation into diurnal and semi-diurnal waves, and gave the analysis of the type curves at the several tidal stations. From Cape Florida and along the keys, and up the western coast of the peninsula to St. George's, the tides are of the half-day class, with a large diurnal inequality; from St. George's, (which belongs to the day class,) to Southwest Pass, they are of the day type, the semi-diurnal tide almost disappearing; at Dernière isle, Calcasieu, and Galveston, they resume, as a rule, the half-day type, and lose it almost completely at Aransas and the mouth of the Rio Grande. The Dernière isle, and, less distinctly, the Calcasieu tides, show cases of interference in the semi-diurnal wave, two high waters being at times easily traced in the semi-diurnal curves.

The character of the tidal phenomena themselves, the peculiarities in configuration and in depth of the basin, the limited extent over which our researches spread, and various other circumstances, contribute to render this work less satisfactory than the former. Some of these will, in the end, disappear as the Gulf is more fully explored in the progress of the survey. Our information thus far extends to but one entrance of the basin—that by the Gulf of Florida—and of this to but one shore; while of the nature of the tide wave, which enters from the Caribbean sea, through the straits between the western end of Cuba and the eastern end of Yucatan, we have no reliable information. Some of these causes render general speculation premature, and lie at the very threshold of attempts to trace out the great interference problems which present themselves.

The progress of this discussion has also shown that observations of longer period are necessary in many cases to give data for conclusive results. This of itself is a great point gained, and the practical results for the charts of this coast have themselves repaid all the labor which has been expended on the observations. Navigators were absolutely without information, other than the most vague, in regard to the tides of the Gulf.

* Proceedings of the American Association for the Advancement of Science, Providence meeting, 1855, p. 152; and Am. Jour. Sci. and Arts, January 1856, p. 28.

The hourly observations at each station being plotted in diagrams upon a suitable scale, the curves of observation were decomposed by the graphical method introduced by Mr. Pourtales into a diurnal and semi-diurnal curve. It may be proper to observe here that several comparisons have been made between this method and that which I had formerly used by the sine curves, and with generally coincident results. The graphical method, besides being less laborious, is free from the hypothesis of the sine curve. These decompositions were made chiefly by Messrs. Fendall and Heaton, of the tidal party, and occasionally by Prof. Pendleton and Mr. S. Walker.

That the diurnal wave is the principal feature in these tides will appear from the annexed table, (No. 1,) which gives the names of the tidal stations, the average rise and fall of the tide at each, and the height of the diurnal and semi-diurnal waves composing the observed tides.

TABLE I.

Stations.	Height of semi-diurnal tides.	Height of diurnal tides.	Height of observed tides.
	Feet.	*Feet.*	*Feet.*
Cape Florida	1. 6	0. 2	1. 5
Indian key	1. 9	0. 6	1. 8
Key West	1. 2	0. 7	1. 4
Tortugas	1. 0	1. 0	1. 2
Egmont key	1. 1	1. 6	1. 4
Cedar keys	2. 4	1. 5	2. 5
St. Mark's	2. 2	1. 8	2. 2
St. George's island	0. 2	1. 6	1. 1
Pensacola	0. 2	1. 1	1. 0
Fort Morgan, (Mobile bay)	0. 2	1. 1	1. 0
Cat island	0. 3	1. 2	1. 3
Southwest Pass	0. 2	1. 2	1. 1
Dernière isle	0. 4	1. 6	1. 4
Calcasieu	1. 3	1. 5	1. 1
Galveston	0. 5	1. 1	1. 1
Aransas	0. 5	1. 3	1. 1
Brazos Santiago	0. 3	0. 8	0. 9

Table No. 2 shows the periods during which the tidal observations were made, and the names of the observers.

TABLE 2.

Tide stations on the Gulf of Mexico, the results of which are discussed in this paper.

No.	Stations.	Date of observation.	Kind of gauge.	Observers.
1	Cape Florida, Florida	April 22, to October 31, 1854	S. R.*	L. E. Tansill.
2	Indian key. "	January 21, to April 16, 1855	S. R.	do.
3	Key West "	April 20, 1850, to December, 31, 1851	Box	W. Lane and G. W. Goss.
4	Tortugas "	April 1, to June 2, 1855	S. R.	C. T. Thompson and F. Buxton.
5	Egmont key "	April 22, to August, 23, 1854	"	C. T. Thompson.
6	Cedar keys "	January 10, to March 16, 1852	Box	G. Würdemann.
7	St. Mark's "	November 3, 1854, to March 2, 1855	S. R.	C. T. Thompson.
8	St. George's isl'd "	April 11, to August 16, 1852	Box	G. Würdemann.
9	Pensacola "	August 27, to October 31, 1852	"	do.
10	Fort Morgan, Alabama	May 20, 1850, to May 26, 1851	"	do.
11	Cat island, Louisiana	December 29, 1847, to Feb'ry 13, 1849	"	G. Würdemann and R. T. Bassett.
12	Southwest Pass "	November 19, 1852, to March 28, 1853	"	G. Würdemann.
13	Dernière island "	April 5, to June 12, 1853	"	do.
14	Calcasieu "	February 24, to May 26, 1854	S. R.	do.
15	Bolivar Point, Texas	October 1, 1853, to June 1, 1854	"	L. E. Tansill.
16	Galveston "	March 21, 1851, to January 1, 1853	Staff	G. Price and F. Muhr.
17	Aransas Pass "	November 1, 1853, to Jan'ry 31, 1854	Box	G. Würdemann.
18	Brazos Santiago "	July 7, to October 13, 1853	"	do.

* Self-registering tide-gauge.

Diagram (No. 1, Sketch No. 35) shows these results graphically. A curved line corresponding to the general outline of the shore, cutting off its irregularities, is drawn on the chart of the Gulf coast, and then developed into a straight line. Thus the tidal stations are plotted at their distances from each other, measured along the general line of the coast. For use by navigators, any intermediate stations may be marked in in the same way, and a rough approximation to the character of the tide be obtained by the interpolation.

The least observed height is 0.9 feet at Brazos Santiago, and the greatest 2.5 feet at Cedar keys. The least height of the average semi-diurnal tide is 0.16 feet at Southwest Pass, and the greatest 2.40 feet at Cedar keys. The least height of the average diurnal tide is 0.21 feet at Cape Florida, and the greatest 1.80 feet at St. Mark's. Of course these numbers are, for reasons easily seen, only approximations.

As we enter the Gulf of Mexico by the Straits of Florida the height of the tide first increases, then decreases. Passing into the bight at the upper end of the Florida peninsula, the rise is greatest; west of St. George's it diminishes, to rise again in the bight formed by the southern coast of Louisiana and the eastern coast of Texas.

In the decompositions here traced, and in the very laborious discussions, tentative and final, of the whole of the observations upon which this paper is based, I would acknowledge the great assistance derived from the labors of Assistant L. F. Pourtales, in charge of the tidal division of the Coast Survey. The unwearied assiduity of his own labors, and his intelligent supervision of the work of others, has been felt at every step in the progress of these investigations. They have required on his part great resources of ingenuity, patience, and knowledge.

In discussing semi-diurnal tides, the luni-tidal interval of high or low water varying only from a certain mean within moderate limits, affords a cardinal datum (the establishment) for the times. In the diurnal tide this datum is wanting. The law of the change of the diurnal tide, as expressed in the formula of Professor Airy, (Tides and Waves, Encyc. Metrop., p. 254, art. 46,) is, in general, represented, but the great flatness in the form of the curves, at particular relations of the moon's right ascension and declination, required by the formula, does not occur. The general form of these curves is shown upon the diagram No. 2, (Sketch No. 35,) where the abscissæ represent the days, and the ordinates the luni-tidal intervals of high water. About the maximum of declination for some four to six days the luni-tidal intervals are moderately constant, and the average of these is what I have taken for a comparison of the luni-tidal intervals to trace the progress of the diurnal wave. The variations from day to day being less than the probable irregularities in the times of high water and the uncertainties in the observations, these means give suitable numbers for comparison. The result would not have been greatly different had only a few of the observations at either end of the declination period been thrown off, but, after examination, we found these numbers to present apparently the best results.

At four of the stations—namely, Key West, Fort Morgan, Cat island, and Galveston—hourly observations were continued during a year and upwards, and the decompositions in all the cases but Cat island embrace that period. The annual change of diurnal establishment is very clearly seen in all these cases, and is shown in the diagram No. 3, (Sketch No. 35.) The law of the change is beautifully developed in the larger tides of the Western Coast, and, as deduced from the San Francisco observations, is shown upon the same diagram. In all the cases, the actual computed results for the different half-monthly periods are represented by the broken lines on the diagram and the line representing the curve is drawn with a free hand among the points. The general resemblance of these curves (with, however, different maximum ordinates) is very striking, showing that the law of the change is the same, only the coefficients of the fractions varying.

On the diagram of the San Francisco results, the curve derived from Professor Airy's formula (Theory of Tides and Waves, Encyc. Metrop., p. 254, art. 46) is drawn, as well as that from observation, and the general conformity is quite striking. In making use of the curves, as expressing the law of annual change, one of the branches has been turned over upon the other, so as to use the mean of the two periods of six months.

At the other fourteen stations on the Gulf of Mexico the observations were continued from one to three lunations, and fell in different parts of the year. To reduce these, therefore, to the same period of the year, it is necessary to employ the data from the localities where the whole annual change was embraced. The results are plotted on the several diagrams: those from the Brazos to Southwest Pass, on the curve from Galveston; those from the Southwest Pass to St. George's, on the curve from Fort Morgan, and those from St. George's to Cape Florida, on the curve from Key West, (Sketch No. 35.) There is, except in one case, a general comformity in the observed changes and in those deduced from the other comparisons—at least there are no greater contradictions than those presented by the observations from which the mean curves are drawn. From these plottings the correction necessary to reduce the results to the mean of the year are deduced, and the annexed table (No. 3) shows the diurnal interval, as deduced directly from the observations, and as corrected. It is satisfactory to see that the correction makes the results more conformable to law, increasing, therefore, the probability that the correction is rightly applied, and is approximately correct in magnitude.

TABLE 3.

No.	Stations.	Latitude N.	Longitude W.	Longitude in time.	Mean diurnal luni ti. interval near max. of moon's dec.	Sum of Long. and Estab.	Correction for transit.	Correction for depth.	Correction for yearly variation of diurnal luni. interval.	Corrected cot. hour.
		° ′	° ′	h. m.	h. m.				h. m.	h. m.
1	Cape Florida	25 40	80 9	5 21	14 27	19 48	0 27	0 20	+ 0 18	19 19
2	Indian key	24 52	80 44	5 23	17 00	22 23	34	20	— 0 42	20 47
3	Key West	24 27	81 53	5 28	18 32	24 0	37	19	0 0	23 4
4	Tortugas	24 34	82 59	5 32	18 5	23 37	36	10	+ 0 43	23 34
5	Egmont key	27 36	82 46	5 31	19 19	24 50	39	20	+ 0 1	23 52
6	Cedar key	28 58	82 57	5 32	22 27	27 59	43	45	— 0 57	25 34
7	St. Mark's	30 0	84 11	5 37	21 56	27 33	42	22	+ 0 20	26 49
8	St. George's island	29 35	85 12	5 41	19 41	25 22	42	25	+ 0 37	24 52
9	Pensacola	30 18	87 15	5 49	21 28	27 17	42	17	+ 0 22	26 40
10	Fort Morgan	30 9	88 0	5 52	21 21	27 13	42	14	0 0	26 14
11	Cat island	30 6	88 38	5 55	22 21	28 16	43	1 21	— 0 11	26 1
12	Southwest Pass	28 56	89 22	5 57	19 28	25 25	39	21	+ 0 59	25 24
13	Dernière island	28 58	90 58	6 4	19 19	25 23	38	24	+ 1 37	25 58
14	Calcasieu	29 40	93 21	6 13	19 22	25 35	39	17	+ 1 27	26 6
15	Bolivar Point	29 23	94 46	6 19	21 40	27 59	43	12	+ 1 24	28 28
16	Galveston	29 18	94 41	6 19	22 29	28 48	43	30	0 0	27 35
17	Aransas Pass	28 15	96 31	6 26	19 46	26 12	40	17	+ 0 43	26 0
18	Brazos Santiago	26 6	97 10	6 29	20 45	27 14	41	15	— 0 56	25 22

The first column of the annexed table (No. 3) contains a number for reference; the second, the name of the tidal station; the third, fourth, and fifth, the latitude and longitude, the latter in degrees and in time; the sixth, the luni-tidal interval about the maximum of declination; the seventh, the sum of this last-named number and the longitude in time; the eighth, the correction to reduce the observations to the same transit; the ninth, the correction for depth, carrying them by the law of depth to deep water; the tenth, the correction to reduce the observed luni-tidal interval at maximum to the corresponding mean of the year; and the eleventh, the corrected co-tidal hour.

The table enables us satisfactorily to trace the diurnal wave from Cape Florida to the Tortugas, across by the deep water of the Gulf to Southwest Pass, at the entrance of the Mississippi, and from this line of deep water to the western coast of the peninsula of Florida, by Egmont key, (Tampa,) Cedar keys, St. Mark's and St. George's, and in the bay between Southwest Pass and St. George's; by Cat island, Fort Morgan, Pensacola, and St. George's. Again in the bight between Southwest Pass and the Rio Grande, to Isle Dernière, the Rio Grande, Calcasieu, and Aransas, up to Galveston.

In obtaining the general direction of the co-tidal lines, I have followed the method of grouping used in my former papers, in the form given by Professor Lloyd. It is easy to obtain a general view of the movement of the diurnal wave in this way, but the selection of the groups required a tedious set of trials, and the discussion of many groups which appeared natural proved very unsatisfactory. The burden of the computation for this work has fallen upon Mr. John Downes.

Table No. 4 shows the groups selected, with a letter attached for reference; the names of the stations constituting the groups; the mean latitude and longitude and co-tidal hour of the group; the values of the coefficients of each; the angle of the co-tidal line with the meridian; the velocity of movement of the wave, and the same in miles per hour.

TABLE No. 4.

	Stations.	Mean longitude.	Mean latitude.	Mean co-tidal hour.	M — Difference of co-tidal hour for one geog. mile of— Longitude.	N — Difference of co-tidal hour for one geog. mile of— Latitude.	Angle $\left(\tan.-\frac{N}{M}\right)$ Co-tidal angle.	$\sqrt{M^2+N^2}$ Diff. of co tidal hour correspond'g to one geog. mile perpend. to co-tidal line.	Miles per hour, tidal wave.
		° ′	° ′	h. m.			° ′		
A	Cape Florida, Indian key, Key West	80 55	25 0	21 3	— 1.978	— 0.509	— 14 28	2.052	29.2
B	Indian key, Key West, Tortugas	81 52	24 38	22 28	— 0.890	— 3.240	74 38	3.360	17.8
C	Key West, Egmont key, Cedar keys	82 32	27 0	24 10	5.251	1.695	— 17 53	5.518	10.9
D	Cedar keys, St. Mark's, St. George's	84 7	29 31	25 45	1.095	2.358	— 65 5	2.600	22.7
E	St. George's, Pensacola, Fort Morgan	86 49	30 1	25 55	0.055	2.645	— 88 49	2.645	22.7
F	Cedar key, St. Mark's, St. George's, Pensacola, Fort Morgan, Cat island, Southwest Pass	86 31	29 43	25 56	0.048	0.911	— 86 58	0.910	66.0
G	St. George's, Pensacola, Fort Morgan, Cat island, Southwest Pass	87 41	29 49	25 50	— 0.275	1.092	75 52	1.127	53.1
H	Southwest Pass, Dernière island, Calcasieu, Galveston, Aransas, Brazos	93 45	28 28	26 4	— 0.241	0.944	63 19	0.974	61.6

On the character of these groups, I would remark as follows: Groups A—Cape Florida, Indian key, and Key West; and B, Indian key, Key West, and Tortugas—give a natural movement for that of the wave, though showing a more abrupt change than is probably real. The computed and observed co-tidal hours differ at the greatest but one minute and a quarter. The next group, C, gives a satisfactory idea of the movement of the wave passing round the Tortugas and up along the coast of the peninsula, over the extensive flat which borders it. The next group, D—Cedar keys, St. Mark's, and St. George's—presents a perfect agreement between the computed and observed co-tidal hours, and a direction and velocity agreeing with what might have been supposed. The same is true for group E—St. George's, Pensacola, and Fort Morgan. The more general group F, including the stations from Cedar keys to Southwest Pass, agrees in its indications with those given by the partial groups, as does also G, including the stations from St. George's to Southwest Pass. In passing westward and southward, the direction of the line changes rapidly, and no satisfactory adjustment by groups could be made. From Southwest Pass to Brazos Santiago, the smaller groups give decidedly anomalous results for adjacent stations, pointing to the more general arrangement of the lines shown by group H, composed of Southwest Pass, Dernière Isle, Calcasieu, Galveston, Aransas, and Brazos Santiago.

The agreement of the cotidal hours, as computed and observed, is less satisfactory in the larger groups than in the smaller ones, as might be expected.

On the map No. 5, (Sketch No. 36,) a rough outline of the Gulf coast is traced, and the cotidal hours are marked near the stations. The mean cotidal line for each group, and the hour before and after the mean hour, are marked on the map, showing the direction and velocity of the diurnal wave as given by the groups. From a consideration of these and of their necessary connection, the cotidal lines are approximately drawn.

The great cotidal line of the Gulf, as traced upon the chart, is that of twenty-six hours. The cotidal lines of nineteen to twenty-three hours only appear on the coast of the Florida keys. The line of twenty-four hours is well marked near Egmont key, Tampa. The line of twenty-six hours is at the head of the bight between St. George's and Cedar keys, and in that near Cat island. The line of twenty-seven hours appears only at the head of the bay formed by the coasts of Texas and Louisiana.

SEMI-DIURNAL TIDES.

The table (No. 5) of semi-diurnal tides, is in the same form as No. 3 for diurnal tides. It contains a number for reference, the name of the station, its latitude, the longitude in arc and in time, the establishment, the same in Greenwich time, the correction for transit and for depth, and the corrected cotidal hour.

TABLE No. 5.

No.	Stations.	Latitude.	Longitude.		Establishment of half daily tide.	Establishment Greenwich time.	Correction—		Corrected cotidal hour.
			In arc.	In time.			For transit.	For depth.	
		° ′	° ′	h. m.	h. m.	h. m.	m.	m.	h. m.
1	Cape Florida	25 40	80 9	5 21	8 17	13 38	— 17	— 20	13 1
2	Indian Key	24 52	80 44	5 23	8 2	13 25	— 16	— 15	12 54
3	Key West	24 27	81 53	5 28	9 10	14 38	— 18	— 19	14 1
4	Tortugas	24 34	82 59	5 32	9 22	14 54	— 19	— 10	14 25
5	Egmont Key	27 36	82 46	5 31	11 26	16 57	— 23	— 20	16 14
6	Cedar Key	28 58	82 57	5 32	13 9	18 41	— 26	— 45	17 30
7	St. Mark's	30 0	84 11	5 37	13 37	19 14	— 27	— 22	18 25
8	St. George's island	29 35	85 12	5 41	14 59	20 40	— 30	— 25	19 45
9	Pensacola	30 18	87 15	5 49	10 53	16 42	— 22	— 17	16 3
10	Fort Morgan	30 9	88 0	5 52	11 9	17 1	— 22	— 14	16 25
11	Cat island	30 6	88 38	5 55	12 53	18 48	— 26	— 81	17 1
12	Southwest Pass	28 56	89 22	5 57	10 23	16 20	— 21	— 21	15 38
13	Dernière island	28 58	90 58	6 4	13 37	19 41	— 27	— 24	18 50
14	Calcasieu	29 40	93 21	6 13	14 56	21 9	— 30	— 17	20 22
15	Bolivar Point	29 23	94 46	6 19	16 47	23 6	— 34	— 12	22 20
16	Galveston	29 18	94 41	6 19	------	------	------	— 30	------
17	Aransas Pass	28 15	96 31	6 26	14 30	20 56	— 29	— 17	19 10
18	Brazos Santiago	26 6	97 10	6 29	14 45	21 14	— 29	— 15	20 30

In tracing the semi-diurnal wave, as it enters the Straits of Florida, we find, after a slight contradiction between Cape Florida and Indian Key, a general increase of the cotidal hour in the right direction to the Tortugas. The semi-diurnal wave here gives a difference of time between Cape Florida and the Tortugas of but 1*h.* 24m., while the diurnal wave gave 4*h.* 15*m.* The lagging of the diurnal wave, which at Cape Florida was 1*h.* 44*m.*, at Indian Key is 3*h.*22*m.*, at Key West 4*h.* 31*m.*, and at the Tortugas 4*h.* 23*m.*

The semi-diurnal wave passes across the gulf to the Southwest Pass, as did the diurnal. The time of crossing by the semi-diurnal wave is, however, 1*h.* 13*m.*, while by the diurnal wave it was 1*h*. 50*m*. The lagging of the diurnal wave behind the semi-diurnal, which at the Tortugas was 4*h*. 23*m*., at the Southwest Pass is 4*h*. 49*m*. The mean computed depth of the portion of the gulf traversed by the wave from the semi-diurnal wave is 1,666 fathoms, and from the diurnal 666 fathoms, for the mean result of the two 1,000 fathoms. The actual depth has not been ascertained, but probably does not exceed 1,000 fathoms.

From this line of deep water the semi-diurnal wave reaches the stations on the western coast of the Florida peninsula in their order from south to north and west. The movement west of St. George's appears to be in the order of Pensacola, Fort Morgan, and Cat island, while, for the diurnal wave, it was Cat island, Fort Morgan, and Pensacola. At Southwest Pass there is a sudden increase of establishment, as if another semi-diurnal wave brought the tide there; the mean establishment of the six stations west of Southwest Pass is 20*h*. 15*m*., while that of the six east of it is 17*h*. 31*m*., a difference of about three hours. This table, with the remarks already made in regard to the appearance of two high waters in the curves for Isle Dernière and Calcasieu, indicate a system of interferences yet to be unravelled. As was the case with the diurnal wave, the stations at Isle Dernière and Calcasieu furnish cotidal hours nearly like those of Brazos Santiago and Aransas, and Galveston is later than either.

Upon the whole, then, there is a general resemblance in the motion of the two waves, as assigned by observation, with some considerable discrepancies. The annexed table, No. 6, shows the difference between the establishments for diurnal and semi-diurnal waves at the several stations.

TABLE 6.

Comparison of establishments of diurnal and semi-diurnal tides in the Gulf of Mexico.

No.	Stations.	Diff. between diurnal and semi-diurnal tides. *h.*	*m.*
1	Cape Florida	6	28
2	Indian Key	8	16
3	Key West	9	22
4	Tortugas	9	26
5	Egmont Key	7	54
6	Cedar Key	8	21
7	St. Mark's	8	39
8	St. George's island	5	19
9	Pensacola	10	57
10	Fort Morgan	10	12
11	Cat island	9	17
12	Southwest Pass	10	4
13	Dernière island	7	19
14	Calcasieu	5	53
15	Bolivar Point	6	17
16	Aransas Pass	5	59
17	Brazos Santiago	5	4

When we come to follow these results into the discussion of the groups, they are far from satisfactory. Perhaps this was to have been expected from the circumstances before stated; the groups were nevertheless elaborately examined, though without much fruit.

The table of groups (Table VII) is arranged as for the diurnal tides, containing, as before, a number for reference, the names of the stations, and their latitude and longitude, the values of the co-efficients of each, the angle made by the cotidal line with the meridian, the movement of the wave perpendicular to the cotidal line, expressed by the number of minutes employed in traversing a mile, and the number of miles per hour.

TABLE VII.

Stations.	Mean longitude.	Mean latitude.	Mean cotidal hour.	M. Difference of cotidal hour for one geographical mile of— Longitude.	N. Latitude.	Angle. $\left\{ \text{tang}—\frac{N}{M} \right\}$ Cotidal angle.	$\sqrt{M^2 + N^2}$. Difference of cotidal hour corresponding to one geographical mile perpendicular to cotidal line.	Mil.s per hour of tidal wave.
	° ′	° ′	h. m.			° ′	m.	
A. Cape Florida, Indian key, Key West	80 55	25 0	13 19	—1. 515	1. 151	37 14	1. 902	31. 5
B. Indian key, Key West, Tortugas	81 52	24 38	13 47	—0. 551	—1. 288	—66 49	1. 401	42. 8
C. Egmont key, Cedar key, St. Mark's	83 18	28 51	17 23	0. 049	0. 935	—87 0	0. 935	64. 2
D. Fort Morgan, Cat island, Southwest Pass	88 40	29 44	16 21	—1. 260	1. 887	56 16	2. 269	26. 4
E. Isle Dernière, Calcasieu, Bolivar Point	93 2	29 20	20 31	—1. 246	—1. 517	50 36	1. 963	30. 6
F. Southwest Pass, Dernière island, Calcasieu, Bolivar Point, Brazos	93 7	28 37	19 32	—1. 243	1. 488	50 7	1. 939	30. 9

Groups A and B, composed of Cape Florida, Indian Key, and Key West, and of Indian Key, Key West, and Tortugas, especially the first, give plausible results, and the computed establishments vary but 1.5*m.*, at the greatest, from the observed. I have not been able to form any satisfactory connection between these groups and those on the western coast of the peninsula. The next group which gives a tolerable result is Egmont Key, Cedar Keys, and St. Mark's. In this the direction of the cotidal line, the velocity and the establishment, are satisfactory.

The establishment of St. George's station is irregular, and is very probably erroneous. The semi-diurnal wave is composed of two very small ones, and it has been necessary to reconcile the discrepancies which they presented, sometimes one being the governing tide and sometimes the other.

Group D, composed of Fort Morgan, Cat Island, and Southwest Pass, is the next which gives a good result.

E, composed of Isle Dernière, Calcasieu, and Bolivar Point, and F of all the stations from S. W. Pass to Brazos Santiago, except Aransas, give good results as to direction and velocity. The computed establishment, as in the case of the diurnal wave, present considerable discrepancies from the observed. The least difference is 8.5*m.*, and the greatest 67*m.*

These groups are marked upon the chart (No. 6, Sketch No. 36,) and the cotidal hour next before and after the mean cotidal hour of the groups. An approximation to the cotidal lines from these data is also shown upon the chart. The corrected cotidal hours of the several stations are marked upon the chart.

In comparing the two sets of cotidal lines for the diurnal and semi-diurnal waves, we find a general resemblance in the great bay between the western coast of Florida and the eastern coast of Louisiana, the lines of 24, 25, and 26 of the diurnal tide, on the eastern side of the bay, corresponding generally with 16, 17, and 18 of the semi-diurnal tide, and 25 and 26 hours of the diurnal tide on the western side of the bay, corresponding generally to 16 and 17 of the semi-diurnal. On the southern coast of Florida, by the keys, on the contrary, the lines of 19, 20, 21, 22, and 23 hours, succeed each other rapidly between Cape Florida and the Tortugas, in the diurnal series, while 13 and 14 hours only occur along the same shores in the semi-diurnal tide. On the contrary, in the bay between Louisiana and Texas, or west of Southwest Pass, the lines of 25, 26, and 27 hours only occur at considerable distances in the diurnal system, while 16, 17, 18, 19, 20, and 21 occur in the same space between Southwest Pass and the Brazos Santiago, in the semi-diurnal tide.

I shall continue to collect observations bearing upon the facts discussed in this paper, and to have them worked up, so as to amend the imperfections of the approximate results now presented. There are simultaneous observations at some of the stations, which were formerly examined with but little satisfaction as to the conclusions; these will now be resumed, and may throw additional light upon the results at some of the doubtful stations. The interference problems will be taken up when more extended data give better hopes of a satisfactory solution of them.

APPENDIX No. 36.

Description of the Type-Curves of Tides in the Gulf of Mexico.—(*See Sketch No.* 38.)

On the diagram the rise and fall of the tide at the several localities is represented in the usual way by a curve, the ordinates of which represent the heights of the tide and the abscissæ the times. The heights are marked at the side of the diagrams and the hours at the top. The periods selected for representing the law of rise and fall is that when the diurnal tide is the greatest, or at the moon's maximum of declination, and that when the diurnal tide vanishes or when the moon crosses the equator. The curves selected as types of those representing the law of rise and fall at these periods are chosen for their regularity as unaffected by wind or other causes producing irregular flow or ebb. The types are selected in reference to the diurnal tides because it is the great feature of the gulf tide. The curves of observation are represented in full lines on sketch No. 38, the single divisions of the scale of ordinates being two-tenths of a foot, and of the scale of abscissæ, hours. These curves are decomposed by the method introduced by Mr. Pourtales into diurnal and semi-diurnal curves, the dotted line representing the semi-diurnal, the broken line the diurnal curve. The diagrams are arranged in their order of succession, or of the stations from east to west.

At *Cape Florida* the diurnal curve is very flat, and consequently the tides exhibit the semi-diurnal type, very little disturbed as it comes in from the Atlantic.

At *Indian Key*, *Key West*, and the *Tortugas*, a very regular increase of the diurnal tide is shown in the order named; the semi-diurnal tide, on the contrary, decreases. This combination produces an increased daily inequality, so that at the Tortugas, at the moon's greatest declination, one of the semi-diurnal low waters almost entirely disappears, combining with the preceding high water in producing the appearance of a stand of two or three hours, after which the tide continues rising. This appearance only prevails for one or two days near the moon's maximum declination.

On the western coast of the peninsula of Florida, at *Egmont Key*, (Tampa bay,) the type is nearly the same as at the Tortugas, but with an increased rise and fall. At the *Cedar Keys*, and *St. Marks*, the tides resemble those of Key West, the semi-diurnal tide being distinct, but the diurnal tide producing a large diurnal inequality. The rise and fall increases considerably as we go north.

Between St. Mark's and *St. George's Island* a great change occurs in the character of the tides, the rise and fall becoming small and the diurnal tide being the prevailing one. The semi-diurnal tide is only perceived for three or four days at the time of the moon's crossing the equator. During the rest of the lunation they only affect the prevailing diurnal tides by making them appear to stand at nearly the same height at high water for from six to nine hours. At low water the stand is very short. There is sometimes the appearance of an interference of waves in the decomposed semi-diurnal waves.

At *Pensacola*, Fla., *Fort Morgan*, (entrance to Mobile bay,) *Cat Island*, and *Southwest Pass* of the Mississippi, the semi-diurnal tide is so small as scarcely to disturb the diurnal curve. It can only be perceived by its producing small irregular double tides for two or three days at the time of the moon's crossing the equator. Scarcely any trace of them can be seen when this epoch coincides with the quadratures.

To the west of the mouth of the Mississippi the semi-diurnal tides increase again. At *Isle Dernière*, La., the double tides are quite distinct, though sometimes irregular, for two or three days near the time of the moon's zero of declination. During the remainder of the lunation the diurnal tides prevail, but modified by the semi-diurnal so as to have a stand of from six to ten hours at high water. The semi-diurnal tides indicate a more marked case of interference than at St. George's Island, there being four high and four low waters in twenty-four hours. At *Calcasieu entrance* the semi-diurnal type is plainly marked during the whole lunation. The diurnal inequality is, however, so large, and the rise and fall so small, that to ordinary observation only one high water would make itself apparent in a day, but remaining at a stand or falling very slowly for about ten hours.

At *Galveston* the tides are of the same type as at Calcasieu, but the relation of the diurnal to the semi-diurnal tide is such that the latter would only be seen plainly for five or six days near the time of the moon's zero declination. During the remainder of the lunation there would be the appearance of but one high water in twenty-four hours, with a regular rise from low to high water, followed by a fall for a short distance, then a stand of several hours, and then a regular fall to the next low water. Sometimes the water falls very slowly for nine or ten hours and then increases its rate of fall to a more rapid one.

At *Aransas Pass* and *Brazos Santiago* the semi-diurnal tide becomes again very small, producing double day tides only for two or three days at moon's zero declination, and even then with frequent irregularities. The remainder of the time the diurnal type prevails, but with a long stand at high water, sometimes fluctuating, or a very slow fall lasting nine or ten hours. There is no stand of any consequence at low water.

APPENDIX No. 37.

Report of Sub-Assistant H. Mitchell on the progress of the discussion of the interference tides of Nantucket and Martha's Vineyard Sound.

SIR: The interference tides of section 1, which were so carefully observed during the years 1854 and 1855, have since been the subject of many months' labor in the office. I submit the following as a brief sketch of the progress we have made:

It will be recollected that the region about Nantucket and Martha's Vineyard "is the dividing space between the cotidal hours of XII and XV," and that in this locality the combination of two apparently distinct tide waves is observed. This combination presents the most singular forms, giving at times four high tides in one day near the junction of Nantucket and Martha's Vineyard Sounds, and distorting the tide wave generally, not only in these sounds, but also as observed on the open seacoast of Nantucket and Martha's Vineyard Islands and in Muskeget channel.

The great disturbance of the ocean level thus produced gives rise to those remarkable currents, so peculiar to this neighborhood and often so disastrous to commerce.

The many relations which these phenomena bear to the physical geography of this region, as well as the practical importance of a complete knowledge of them to the immediate wants of navigation, have led us into a study of their most minute details.

The observations were taken at seventeen different stations, and continued till nearly all the movements of the two tide waves were detected.

The usual reduction and plotting of these accumulated observations followed the completion of the field work.

At the two extremes of our field of labor the waves presented the usual approximations to the curve of sines. As we followed them, we noticed the gradual influence of each upon the other, until at intermediate points, carefully determined, all symmetry is lost, and our observations exhibit a compound double-headed wave.

In computing the changes and epochs of these tides we have treated them as distinct waves meeting at sea.

From our simultaneous observations at extreme points, we have computed compound waves, and compared them with those observed at intermediate points. No difficulty was found in thus approximating to the interference forms in a general manner, still our results were not entirely satisfactory. We reversed the process, and taking from the observed compound wave one of the extreme waves compared the residual with the other extreme wave. By the introduction of constants this proved a very successful trial, and a still closer approximation to the facts was obtained. Encouraged by this, we subjected the whole series to this process, which led us also to discern the causes of error, resulting from the former method.

It appears that after these two tide waves pass each other they undergo a rapid decrease in magnitude, causing them to become nearly extinct after proceeding twenty or thirty miles, and that other disturbing causes make their appearance in certain localities, which seem to depend upon the tidal currents, and led us to conclude that, though these currents are among the effects of the interfering waves, they react, and themselves become causes of subordinate irregularities in the rise and fall.

The examination of currents, thus suggested, developed interesting facts. It was ascertained, in a general manner, that throughout the field of our operation the currents are governed by impulses which act nearly simultaneously at all points. By comparing the heights and epochs of the two tide waves it is found that on the restoration of the sea level between them slack current occurs all along the line of interference.* It would appear, therefore, that these currents must be regarded as interchanges of water between two wave systems; and although these, like other tidal currents, flow in opposite directions during alternate periods of about six hours, they can in nowise be distinguished as *ebb* and *flood*. It is ascertained, from the lines of levellings connecting the tidal stations, that the mean level is identical for the two wave systems, that is, the tide waves throughout this region rise and fall above and below a common plane. The transition points of the establishments (that is, the localities where the cotidal hours XII and XV are both found) do not occupy parallel positions in the sounds and the open sea. In the sounds the transition is rapid, and takes place in the narrow strait at West Chop, while a more gradual operation of the same character is observed a short distance to the eastward of Weweeder, south shore of Nantucket. In Muskeget channel occurs another transition of a secondary character, involving more complicated relations. It will be seen, from these considerations, that there exists at certain stages of the tides a large difference of level between the sound and the open sea to the southward. This causes a rush of water through Muskeget channel; and it is to this state of things that the harbor of Edgartown owes its depth of water, its northern and southern openings connecting the sound with the ocean.

I call your attention to the fact that about the same relation is preserved between the surfaces of the water at Brant Point and Weweeder, as between Cape Poge and Wasque; and that all the advantages which the harbor of Edgartown possesses over that of Nantucket would seem to be due to the existence of a southern opening in the former case.

It was observed at the outset of our study that the two principal transition points undergo

* A future study of the most careful kind will have to determine whether along this line the periods of maximum velocities of the currents are similarly dependent upon the greatest disturbance of the sea level between these waves.

simultaneous changes of position, advancing eastward for a period, then retracing their steps, passing to the westward. As such a phenomenon could not occur if the two waves always held the same relative magnitude and rate of travel, we were induced to compare the two waves through all their inequalities. Our results were as follows: though the mean rise and fall of the western wave is less, the half-monthly changes in magnitude are much greater with this than with the eastern wave; moreover, the forms of these curves of half-monthly inequality differ throughout. All the other inequalities differ also in a degree. Thus occurs the alternate predominance of the two waves at their meeting points.

The western, or XII^h wave, as observed at the extremity of our field, (Block island,) is similar in every respect to the general tide wave observed along the coast between this point and Georgia. Its half-monthly inequality in heights is almost identical with that observed at Old Point Comfort, Virginia; even the individual waves compare well at these two places. The eastern or XV^h wave, at the other extremity of our field, (Monomoy,) is far from being similar to the tides of the coast to the northward; its individual tides differ from those of Boston, and its larger irregularities would seem not even to be multiples of those observed at that place.

Diurnal and semi-diurnal elements.—The tides of each of our stations were taken up separately, and resolved into their diurnal and semi-diurnal elements. The semi-diurnal waves exhibit two heads at the locality of the greatest interference, (Falmouth,) one of their meeting points. It is evident that these semi-diurnal waves have not a sine form, since no combination of sine curves can result in a curve with a double head.

The changes in the diurnal wave are followed with difficulty; these waves are very small and irregular; they do not originally hold the same relative character that has been noticed among the semi-diurnal waves of the two tides; nor do they travel at the same speed or submit to the same changes. The mutual interferences among these waves, though producing sensible effects, cannot be traced with that clearness and certainty found in the semi-diurnal element.

Yours respectfully,

H. MITCHELL.

Professor A. D. BACHE,
Superintendent Coast Survey.

APPENDIX No. 38.

Observations to determine the cause of the increase of Sandy Hook, made by the Coast Survey, for the Commissioners on Harbor Encroachments of New York,—by Professor A. D. Bache, Superintendent United States Coast Survey.

(ABSTRACT —.)

It is known as one of the developments by the Coast Survey that the peninsula of Sandy Hook is gradually increasing, growing to the northward into the main ship channel. A spot north of the Hook, where there was 40 feet of water when Captain Gedney made his survey, in less than ten years was nearly bare at low water. The importance of determining the cause of this increase, as leading to the means of controlling it, cannot be over-estimated. The Commissioners on Harbor Encroachments of New York had early attended to this matter, and requested that the necessary observations for its investigation should be made. These were executed under my immediate direction by Sub-Assistant Henry Mitchell, with all desirable zeal and ability.

Various causes had been assigned for this growth, by the action of the waves and the winds, sometimes on the outer side and sometimes on the inner side of the Hook. The effect of the opening and closing of Shrewsbury inlet had also been insisted upon.

To examine these and other probable causes, laborious observations of tides and currents have been made in the vicinity at numerous stations. Careful measurements of the low water line have also been made in connection with these observations, and with others of the force and direction of the wind. Objects easily distinguished from the sand, and of various specific gravities and shapes, have been deposited near the shore of the Hook, to determine the power and direction of the current in the transportation of matter. It is easy to see how laborious all of these observations are, and that some of them are even attended with considerable danger; hence the credit to be given to Mr. Mitchell may be measured. The results of these observations have not yet been worked out in all their detail, but the conclusions from them are perfectly safe, and are of the highest importance. It turns out that this growth of the Hook is not an accidental phenomenon, but goes on regularly and according to determinable laws. The amount of increase depends upon variable causes; but the general fact is that it increases year by year, and the cause of this is a remarkable northwardly current, the amount and duration of which these observations assign along both shores of the Hook, the outer one extending across the whole breadth of false Hook channel, with varying velocity, and the one inside of the Hook extending nearly one-third of the distance across Sandy Hook bay. These currents run to the north during both the ebb and flood tides, with varying rates, and result from those tides directly and indirectly. The inner current is the one by which the flood and ebb tides draw, by the lateral communication of motion, the water from Sandy Hook bay, and the outer is similarly related to these tides as they pass False Hook channel. The velocities and direction which have been found prove this conclusively.

An important observation for navigation results from this, for more than seven hours out of twelve there is a northwardly current running through False Hook channel, which assists vessels entering New York harbor on the ebb tide, and is to be avoided in passing out with the ebb. This northwardly current runs on the inside for eleven hours out of the twelve.

It is the conflict of these two northwardly currents outside and inside, and the deposit of the materials which they carry to the point of the Hook, which causes its growth.

Within a century it has increased a mile and a quarter, and at about the rate of one-sixteenth of a mile a year, on the average, for the last twelve years. Flynn's knoll on the north side of the main ship channel does not give way as the point of the Hook advances. The importance of watching this movement cannot therefore be over stated.

The mode of controlling the growth is obvious from the result obtained. The observations are still continued to obtain the necessary numerical result.

APPENDIX No. 39.

Report of Sub-Assistant H. Mitchell on the investigation of the tides and tidal currents of New York harbor and its dependencies, and at Sandy Hook.

NEW YORK, *November* 22, 1856.

SIR: In developing the system of operation which you have instituted for the investigation of tides and currents, I have endeavored to carry out your instructions, reporting each step as I advanced, and filling in the details as they became necessary.

Limited by your project to no single hypothesis, but required to collect *all the facts*, we have escaped, I am confident, any misapplication of time or means, and are rewarded for our labors by most encouraging results. In obedience to your wishes, I now proceed to make a brief recapitulation of the season's work.

Our operations have been confined to New York harbor and vicinity, and the following are the special localities to which our attention has been directed: vicinity of Sandy Hook, the Kills, Newark bay, and docks of New York and Brooklyn.

Vicinity of Sandy Hook.—The design of our work in this locality being to discover the nature of the causes producing the changes of Sandy Hook, we were required to undertake the closest observation of all the natural agencies at work. Our attention was called not only to the more regular action of tides, currents, and the ordinary wash of the sea, but also to the effects following violent storms and other extraordinary phenomena.

Our first care was to establish a permanent tidal station and assign it to two persons, whose duties were to record the times and heights of the tide, with the usual meteorological notes; also to make periodical surveys of the shore-line of the Hook, and watch the changes of the beach.

Preliminary to a systematic study of the currents, we now proceeded to examine and catalogue the drift matter accumulated upon the shores. By instituting inquiries in the neighborhood, many articles in this catalogue could be traced to wrecks that had occurred on various parts of the coast. We were thus furnished with some hints as to the probable origin and history of deposits with which the Hook is building itself out. Following up these hints, we tested our conclusions by depositing in the sea articles of various specific gravities, and watching for their appearance upon the shores. I will cite here the most striking case in this connection: Near the end of Sandy Hook we found many small household articles, and even human bones, which were ascertained to have drifted thither from the emigrant ship New Era, wrecked at Long Branch two years ago. In order to ascertain whether the same causes were still in operation, we chose a period of quiet weather, and made deposits of sinking bodies, at points along the coast, a short distance from shore. The materials pursued the same path as that taken by the wreck-matter of the New Era, driving on to the same part of the beach after many days.

The regular current observations, commencing along the shores of the Hook, were extended over the neighboring channels and shoals, across Sandy Hook bay, and to a distance of twelve miles down the New Jersey coast. It was our usual plan to occupy these stations simultaneously. One of these being situated in the main channel, was occupied repeatedly as a point of reference, with which we compared the results of the other two. In this way we determined the relative directions and velocities of the currents at different points with considerable accuracy. The observations were taken at short intervals through thirteen or fifteen hours, and the exact times of slack water recorded.

By simultaneous observations we followed the tide wave in its progress along the shore of the Hook and into Shrewsbury river.

The curious distortions which it undergoes in this short journey have been exhibited in diagrams and laid before you. We have here a striking instance of the effect of local causes upon the form of the tide wave.

The effects of the ordinary wash of the sea, the formation of sand bars and ridges, with their accompanying slues; the orderly arrangement of the green sand strata, revealing the former history of the Hook, with many other points of interest, were not allowed to pass unnoticed.

Newark bay and the Kills.—On closing our work at Sandy Hook, we received instructions to commence a series of observations with a view to ascertain the progress of the tide, and its accompanying currents through the Kills, and into Newark bay.

Pursuing these inquiries, we occupied sixteen tidal and above twelve current stations. Our plan of operation was this: an observer on shore noted the time and height of the tide, while a person in his boat, anchored in the stream, recorded the velocity and direction of the current. Several sets of stations were thus simultaneously occupied each day.

The tide of Newark bay is a reunion of two unequal portions of the original tide wave, which have propagated themselves—the one through Arthur Kill, the other through Kill Van Kull. To follow the experiences of these waves it was found necessary to commence our series at Sandy Hook, then dividing, to occupy, in concert, positions suitably arranged along the two avenues which they pursue.

Among these narrow channels and shallow basins the tide wave undergoes constant changes, both in rate of travel and in magnitude. In this way the sea level is greatly disturbed, and strong currents are called into action. Again: the currents, thus engendered, encounter, in their turn, similar disturbances, causing modifications of direction and velocity. In order to discover the relation of results from one station to another, we must depend mostly upon the epochs; we were compelled, therefore, to occupy the different points simultaneously, and to continue our observations through several changes of the tide.

The points in Newark bay, where the flood currents of the two Kills combine, and the ebb currents separate, were determined with considerable accuracy.

The currents of the Blind Channel, or Guzzle, were compared with those of other stations in Newark bay.

In the Passaic river, the tides and currents were observed as high up as Newark.

Our office-work keeping pace in some degree with our field operations, we were able to ascertain each day the progress we were making towards the solution of the questions proposed. We provided in this way against any fruitless expenditure of labor.

Docks of New York and Brooklyn.—We have made observations on drifts and currents about such docks and wharves as you have directed; and although most of these are special cases, we have, I trust, obtained some information which may have a general bearing upon the subject of dock construction. The section of the river or channel in the neighborhood of the dock under examination has usually been included in our field of work. I will enumerate the principal localities in which observations under this head have been made: Atlantic dock and Buttermilk channel, vicinities of Pierrepoint's dock, &c. * * * * *

Very respectfully, yours, H. MITCHELL.

A. D. BACHE, LL. D.,
Superintendent U. S. Coast Survey.

APPENDIX No. 40.

Report of G. Würdemann on tidal observations made at stations between New York city and Albany, on Hudson river.

TIVOLI, N. Y., *November* 1, 1856.

SIR: In conformity with your instructions of September 8, directing the execution of the season's work on the Hudson river, I have the honor to submit the following report on the observations of tides at eight different points above New York city, viz: at Greenbush ferry, (opposite to Albany,) Castleton, Stuyvesant, Tivoli, Poughkeepsie, West Point, Verplank's Point, and Dobb's ferry. At Greenbush ferry, a self-registering tide-gauge was used, and at all the other stations fixed rods graduated to feet and tenths. They were either secured to wharves or fastened to posts, worked into the ground.

At Castleton,	observations	commenced	on August	30.
At Stuyvesant	"	"	"	13.
At Tivoli	"	"	"	12.
At Poughkeepsie	"	"	"	13.
At West Point	"	"	"	9.
At Verplank's point	"	"	"	23.
At Dobb's ferry	"	"	"	23.

Observations were taken every five minutes at high and low water, commencing as near as possible one hour before, and ending thirty or forty minutes after the tide had changed—hourly observations being made during the intervals.

The freshet of the 20th of August washed away the tide-staff at Stuyvesant, and obliged us to take up the self-registering tide-gauge at Greenbush. The first was replaced on the 25th and the latter on the 26th, and the clock started on the 27th of August, after which time it continued to work well. This did not interfere with the work at other stations where the tide ebbed and flowed regularly during the freshet.

An unusually high tide occurred on the 30th of September, at the stations below Stuyvesant. I left Albany on the 29th of September, Castleton and Stuyvesant on the 30th, without perceiving anything unusual in the rise of the tide, and noted a depression in the high water at Tivoli the same evening, as compared with the morning tide. Continuing to visit the stations below, I returned to Albany on the 6th of October, and was surprised to learn of the occurrence of a freshet, which had not raised the water below Stuyvesant.

During a freshet on the 1st and 2d of October, the wharf and tide-gauge at Castleton were submerged. At Stuyvesant three high waters were not taken from the same cause, whilst at Greenbush the water rose over the roof of the house which covers the gauge.

Bench-marks are established at all the stations, and care has been used to make these permanent by inserting copper bolts into stone structures near every tidal station, including that at Greenbush. This, together with the copying of the original records, sketching of bench-marks, &c., has occupied my time since the close of the work.

Very respectfully, your obedient servant,

GUSTAVUS WÜRDEMANN.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 41.

Report to the Superintendent by Assistant L. F. Pourtales, in charge of the field and office-work, relating to tidal observations.

COAST SURVEY OFFICE, *October* 1, 1856.

SIR: I have the honor to submit herewith the annual report of the work done under your immediate direction by the tidal party in my charge. It is divided, as heretofore, into the two heads of field-work and office-work.

FIELD-WORK.—The permanent stations at Boston, New York, Old Point Comfort, and Charleston, on the Atlantic coast, and San Diego, San Francisco, and Astoria, on the Pacific coast, have been kept up. The Boston observer, Mr. Isaac Williams, has continued to give an unbroken series of observations as heretofore. At New York, the tide-gauge had suffered so many interruptions in former winters by being frozen up, that you directed an auxiliary station to be established at the Atlantic Ferry wharf, in Brooklyn, nearly opposite the old station on Governor's island. The great quantities of ice accumulated in the harbor during the past severe winter, showed this step to have been quite necessary, for the self-registering gauge was frozen up for a long time, and some of the structures belonging to it were carried away. The observations at Brooklyn even, made on a staff and a box-gauge, were always difficult, and sometimes impracticable. The same observer, Mr. J. B. Brooks, has now charge of the two stations.

At Old Point Comfort, several stoppages of the self-registering tide-gauge were caused by ice, and once by the gauge being injured by a vessel striking against the wharf; otherwise, the series is pretty satisfactory. The Charleston station, after having been kept up with very little success at Castle Pinckney, was finally transferred to the wharf of the new custom-house; since then it has worked quite satisfactorily.

On the Western Coast, the three permanent stations have continued to give very good results. In addition to the usual meteorological observations made three times a day, they have also been taken hourly every Monday for nearly two years.

Of temporary stations, several were occupied in and about Vineyard Sound, by Sub-Assistant H. Mitchell's party, in 1854, but were received too late to be mentioned in last year's report.

The same was the case with a fine series of tidal and meteorological observations offered by the governor of Russian America, and the more valuable for being simultaneous with those made at several points of the coast by the party under the orders of Lieut. W. P. Trowbridge. Observations are now in progress at several points on the Hudson river, under the charge of Mr. G. Würdemann.* The stations were established, and the observers stationed and instructed by Lieut. Trowbridge. The observations made by Lieut. Trenchard, in St. John's river, in 1854, having presented some striking peculiarities, they were repeated this year by Mr. Würdemann. The discussion is not quite finished, but seems to show that the results will be the same as Lieut. Trenchard's.

The annexed table gives a list of the stations from which observations were received at the office during the year ending this day.

List of tidal observations received during the year ending September 30, 1856.

Sections.	Name of station.	Name of observer.	Kind of gauge.	Station, permanent or temporary.	Time of occupation.		Total days.	Remarks.
					From—	To—		
I	Boston dry dock	I. Williams	Staff	Perm'nt	Oct. 1, 1855	Sept. 30, 1856	365	
	Hyannis, Mass.	Fred. Buxton	Box	Temp'y.	Aug. 8, 1855	Oct. 9, 1855	62	
	Falmouth, Mass.	Geo. W. Coffin	do	do	Aug. 7, 1855	Aug. 31, 1855	24	
	Menemsha, Mass.	V. Swain	do	do	do	Oct. 18, 1855	72	
	Block island, R. I.	G. Würdemann	do	do	do	Oct. 10, 1855	64	
II	Montauk Point, N. Y.	do	Box	do	Oct. 27, 1855	Nov. 28, 1855	32	
	Governor's island, N. Y.	W. Head	S. R.	Perm'nt	Oct. 1, 1855	Sept. 30, 1856	365	Much interrupted by ice.
	Brooklyn, N. Y.	J. B. Brooks	Box	Temp'y.	Dec. 28, 1855	Sept. 11, 1856	277	
	Sandy Hook, N. Y.	J. McHenry	do	do	April 3, 1856	May 6, 1856	33	
III	Old Point Comfort, Va.	M. C. King	S. R.	Perm'nt	Oct. 1, 1855	Sept. 30, 1856	365	Some interruptions by ice.
	Tappahannock, Va.	W. A. Muse	do	Temp'y.	May 26, 1856	do	99	
	Fort Carroll, Md.		do	do	July 8, 1856	Sept. 10, 1856	356	
V	Castle Pinckney, S. C.	J. T. Bee	S. R.	do	July 16, 1855	Dec. 10, 1856	147	
	Charleston, S. C.	W. R. Herron	do	Perm'nt	Feb. 1, 1856	July 1, 1856	151	Establ'd to replace preceding station.
	Beaufort, S. C.	W. H. Hughes	Staff	Temp'y.	April 19, 1855	May 18, 1855	29	
	Stono river, S. C.	R. Blair	do	do	March 19, 1855	May 11, 1855	53	
	Port Royal, S. C.	F. Mulligan	do	do	May 21, 1855	June 4, 1855	33	
	Jekyl island, Ga.	Lieut. Trenchard	Box	do	Feb. 27, 1856	May 2, 1856	65	
VI	Fort Clinch, Fla.	F. A. Rebarer	S. R.	do	Feb. 20, 1856	Sept 30, 1856	223	
	Batton island, Fla.	G. Würdemann	Box	do	May 13, 1856	June 17, 1856	35	
	Fort George island, Fla.	do	do	do	May 14, 1856	do	44	
	St. John's bar, Fla.	do	do	do	May 13, 1856	do	45	
	Dames's Point, Fla.	H. Balsan	Box	do	March 20, 1856	April 5, 1856	16	on St. John's river.
	Hopkins', Fla.	S. B. Jennings	do	do	do	do	16	
	Taylor's Mill, Fla.	G. Wingate	do	do	do	do	16	
	Daniel's Mill, Fla.	C. Keyser	do	do	do	do	16	
X	San Diego, Cal.	A. Cassidy	S. R.	Perm'nt	July 31, 1855	Aug. 1, 1856	367	
	Cuyler's harbor, Cal.	C. J. W. Russell			Nov. 9, 1855	Nov. 23, 1855	14	
	South Farallon, Cal.	N. N. Wines	S. R.	Temp'y.	May 21, 1855	Oct. 10, 1855	142	
	Fort Point, Cal.	H. E. Uhrlandt	do	Perm'nt	July 31, 1855	Aug. 1, 1856	367	
XI	Astoria, Oregon	J. Wayne	do	do	do	July 30, 1856	365	
	Cape Flattery	Lieut. Trowbridge	do	Temp'y.	June 4, 1855	Sept. 12, 1855	100	
	Port Townsend	J. R. Bergan	do	do	June 2, 1855	do	101	
	Steilacoom, W. T.	D. J. Gleeson	do	do	July 21, 1855	Oct. 24, 1855	95	
	Nootka Sound	C. J. W. Russell	Staff	do	June 28, 1855	Sept. 11, 1855	75	
	Sitka, Russ. Amer.	Osinin & Perkoff			June 5, 1855	Sept. 4, 1855	91	Kindly furnished by the Russian gov'r.

OFFICE-WORK.—In the office the ordinary reductions of the observations, as they come from the field, have been made as soon after their receipt as possible, so as to be able to point out defects to the observer, and to be ready to meet the demand for tide-tables or other data from the office. This work was chiefly executed by Messrs. Blanchard, Evans, and Bassett.

* Appendix No. 40.

The long and laborious discussion of the Boston tides by Mr. Avery was brought to a close. Tables for prediction of tides were prepared by him from the constants obtained, and have given very satisfactory results when tested. This subject has been fully explained by you, in a paper read before the American Association for the Advancement of Science, in Albany.

By your direction a whole year's observations at San Francisco were plotted on a convenient scale and decomposed into the diurnal and semi-diurnal tides by the graphical method. Then the luni-tidal intervals were formed and compared with Airy's formula. This whole matter is now in your hands for discussion. Messrs. Downes & Fendall were employed on it—the former in the computations, and the latter in the graphical part and some of the computations.

The simultaneous observations made under Lieutenant Trowbridge's direction on the Western Coast were also decomposed by Mr. Fendall, and the results tabulated. They are also now in your hands for investigation of the comparative rate of progress of the diurnal and semi-diurnal tide waves.

During the preparation by you of a paper on the co-tidal lines of the Gulf of Mexico, it was found necessary to make a large number of new decompositions of the curves of observations at the different stations. They were made principally by Mr. Fendall, (who also prepared the diagrams to illustrate the papers,) and some of them also by Mr. S. Walker and Professor Pendleton. The computations of the groups selected by you were made by Mr. Downes.

The Boston and San Diego observations have been grouped for daily inequality by Lubbock's method, and compared with his formula, by Mr. Kincheloe. The results are yet under discussion.

The above are the main points of the work done, but, in addition to it, numerous smaller computations were made which could not well be detailed here.

Respectfully submitted.

L. F. POURTALES,
Assistant U. S. Coast Survey, in charge of Tidal Division.

Prof. A. D. BACHE, LL. D.,
Superintendent U. S. Coast Survey.

APPENDIX No. 42.

Report of Lieutenant W. P. Trowbridge, U. S. Engineers, assistant in the Coast Survey, on the method pursued in conducting tidal observations on the Western Coast of the United States.

WASHINGTON, D. C., *June* 22, 1856.

SIR: I have the honor to submit the following recapitulation of the results of my operations on the Pacific coast during the last three years as chief of the tidal party of that coast.

Systematic observations on the tides of the Pacific along the coast of California, Oregon and Washington Territories, were commenced in April, 1853, under instructions received from you at Washington in March of that year, by which I was assigned to the duty of conducting the observations contemplated.

The observations were continued three years according to the plan first proposed; and the results having been regularly transmitted to the office, accompanied by detailed reports from time to time on the progress of the work, it only remains for me to make a few remarks on the general character of the results.

By your instructions, above referred to, the investigation of the tidal phenomena was made the special object of my expedition to the Western Coast, and, accordingly, the organization of my party and all my operations were planned with sole reference to one object, viz: obtaining reliable data for the determination of the laws of the tides. Meteorological observations formed a necessary part of the scheme proposed, and magnetic experiments were also required when they could be made without interfering with the main object of the work.

The extent of coast embraced in the scheme of observations was ten to twelve hundred miles—from San Diego on the south to the western extremity of Vancouver's island on the north—the whole of which is remarkably destitute of harbors or anchorages. San Francisco is the only harbor above San Diego which can be entered safely at all seasons. There are numerous points along the coast where vessels can lie during the summer months; but in these cases, with few exceptions, they are exposed to heavy swells which break in a heavy surf upon the shores. Settlements are necessarily few and isolated, and inaccessible by land.

These circumstances rendered the execution of any definite plan with regard to the selection of stations very difficult. Some points at which it was desirable to make observations were absolutely inaccessible on account of the mountainous character of the coast, which prevented any approach either by land or sea; at others, the heavy surf which constantly breaks along the shore prevented the erection of any structures for establishing the gauges. It was therefore found necessary to take advantage of such points as offered success, and to select the season most advantageous under the circumstances.

A list of the stations occupied, with a sketch of the coast showing the location of the different gauges, is given in my last report, together with statistics of the observations. Of seventeen stations occupied, all except three or four were selected for determining the tide wave of the coast, uninfluenced to any great degree by harbor obstructions.

Three self-registering gauges were first established near the southern, middle, and northern parts of the coast, which have been constantly running since the summer of 1853. At the other stations the observations were usually continued during a period of two or three lunations. I directed personally in the erection of all the gauges except three or four, which were entrusted to my assistant; but as it was not possible for me to remain near them, I took special pains to select faithful and reliable observers, and to furnish them with everything necessary to the uninterrupted progress of the work. During the whole period, no observations were rejected or lost on account of inattention or neglect, though temporary interruptions sometimes occurred, occasioned by storms or other unavoidable causes.

The construction of piers on which to place the gauges proved the greatest difficulty, as well as the most expensive part of the work. As the self-registering machines were regulated by pendulums, it was necessary to make a perfectly solid basis for their support, and the difficulty of doing this in a heavy surf, with a small force, was very great; and the uncertainty attending the stability of such structures was often extremely perplexing.

The results, however, are better than I could reasonably expect; for the time observations, chronometers were used, which were always regulated and set to the local time of the place.

It is not necessary for me to enter into more detailed explanations, as I can more safely refer to the notes and records which accompanied the observations, and which were intended to furnish all necessary facts connected with them.

Very respectfully, your obedient servant,

W. P. TROWBRIDGE,
U. S. Engineers, Assistant U. S. Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey, Washington, D. C.

APPENDIX No. 43.

On the effect of winds in varying the level of the water in Albemarle Sound, by L. F. Pourtales, assistant in the Coast Survey.—(*Sketch No.* 16.)

During the progress of the hydrographic survey of Albemarle sound, numerous observations were made of the height of the water and the force and direction of the wind, in order to obtain the mean level of the surface, to be used as a plane of reference for the reduction of the soundings.

But before giving the results of the investigation made to determine the effects of the wind on the height of the water, it will be useful to say a few words about the shape and general character of Albemarle sound, as far as they have a bearing on the subject.

The greatest length of the sound, from the mouth of Roanoke river to Shellbank Point and Collington's island, is about fifty-six miles; its breadth goes increasing from west to east, beginning with three or four miles, and reaching about fourteen at its widest part, opposite the mouth of the Pasquotank. The greatest depth is only twenty-four feet, and the average about twenty. It is pretty uniform, the western end of the sound being, however, somewhat deeper than the eastern. The direction of the greatest axis of the sound is about W. by S.

All the rivers falling into the sound on its northern shore run in a southeast direction—a characteristic feature of the water-courses descending from the eastern slope of the Alleghanies—and they all form shallow, elongated bays, as nearly all the rivers of this section of country do, and as may be seen exemplified in the tributaries of Chesapeake bay. Another peculiarity of the mouth of the rivers emptying on the north side of Albemarle sound is to have a long point of land or a shoal stretching out from the western side towards the east, directly across the mouth. The southern shore of the sound is broken by two rivers only, one of them the Alligator river, forming a considerable bay, running due north, and opening directly opposite the mouth of the Pasquotank.

The observations under discussion were—1st, one year's observations in 1847 and '48, at the Pasquotank light-boat, when the height of the water and the direction and force of the wind were recorded daily at midnight, and at every hour from 4 o'clock a. m. to 8 o'clock p. m.

2d. Similar observations made at Caroon's Point, from May 5 to November 19, 1848.

3d. Observations made in Edenton bay, from May 17 to June 13, 1849.

An examination of the observations soon showed that no fluctuation due to a lunar tide exists in Albemarle sound, as might have been anticipated, considering the distance and smallness of the communication between the body of water and the ocean.

The heights of the water, as recorded on the tide-staff, were then grouped according to the wind blowing at the time of observation. The observations made during the rise of the surface were kept separate from those made during the fall. The means were then taken, and the following tables formed, which are also represented on the accompanying diagrams.—(Sketch No. 16.)

Direction of wind.	Pasquotank light-boat.		Caroon's Point.		Edenton bay.	
	Height above mean.	No. of observations.	Height above mean.	No. of observations.	Height above mean.	No. of observations.
	Feet.		*Feet.*		*Feet.*	
N.	— 0. 19	806	— 0. 11	431	— 0. 12	35
N.E.	— 0. 17	1306	— 0. 04	715	— 0. 03	58
E.	— 0. 10	907	— 0. 10	312	0. 08	76
S.E.	0. 13	843	— 0. 01	264	— 0. 02	22
S.	0. 18	1001	0. 15	252	— 0. 03	37
S.W.	0. 16	1478	0. 17	563	0. 02	35
W.	0. 15	1028	0. 21	312	0. 05	16
N.W.	— 0. 17	1017	— 0. 07	437	— 0. 04	18

Thus it will be seen that, at the Pasquotank light-boat, the north wind depresses the water most, whilst the south wind gives it its greatest elevation. S. E., S.W., and W. winds have nearly the same effect as the south wind. This accords very well with the position of the light-boat. The south wind has the full sweep of the Alligator river in its greatest length, and of Albemarle sound in its greatest breadth. The S. E. and S.W. winds have likewise a large extent of water to act on. The west wind does not blow so favorably for this particular station, at a first glance, but it must necessarily have a powerful effect on the body of Albemarle sound, which must be felt at the Pasquotank light-boat. The other winds all blow off shore, and must necessarily depress the water.

At Caroon's Point the effects of the wind appear quite anomalous—off-shore winds elevating the surface, whilst the north wind, which has all the waters of Currituck sound to act upon, produces the greatest depression. We must look for an explanation in the probable effect of the winds on the waters of Pamplico sound, the motions of which must make themselves felt at Caroon's Point, through Croatan sound. Thus, the north wind acts on Pamplico sound with great force, and produces a depression in its northern part, sufficient to draw off more water from Caroon's Point than Currituck sound is able to supply. The south wind would naturally have the opposite effect. East and west winds, however, acting on Albemarle sound in its *greatest* dimension, and on Pamplico sound in its least, the effects felt at Caroon's Point ought to be those pertaining to Albemarle sound, as the observations indicate.

The observations in Edenton bay extend over too short a period to give very reliable results. They indicate, however, the greatest elevation of the water as due to the east wind, as must be the case.

Observations are wanting to show the effects of rain or drought, which ought to be well marked, as the drainage of a large extent of country finds its way into these waters.

APPENDIX No. 44.

Notes on the winds of the coast of the United States on the Gulf of Mexico—by A. D. Bache, Superintendent United States Coast Survey.—(Sketch No. 37.)

The observations were made in connection with those of the tides, at the Coast Survey stations at Key West, Fla., Fort Morgan, Ala., and Galveston, Texas, and included the direction of the wind and its force by estimate. The description of the means of observation, of the scale used in estimating its force from 0 to 10, and of the mode of obtaining from the observations the quantity of wind blowing from different directions, given to the American Association for the Advancement of Science at the Charleston meeting, and published in its proceedings, apply to the present observations and results. The comparative diagrams are plotted on a compass rose, the quantity of wind from each direction for the month being laid off from the small circle described about the centre of the rose, upon a scale upon which fifteen hundred miles correspond to one inch. There is one diagram for each month, and the average of the year is represented on a scale of 18,000 miles to the inch.

The results at the different stations are shown in different kinds of lines, and the distances representing the quantity of air moving from the several points are, for greater distinctness, laid off from a small circle described about the centre of the compass rose as a centre. The observations at Key West were made by Mr. Goss, at Fort Morgan by Mr. Würdemann, and at Galveston by Mr. Muhr. The diagrams were made by Sub-Assistant Fairfield.

The dates of observations were from June, 1851, to June, 1852, for Key West; from June, 1847, to June, 1849, for Fort Morgan; and from July, 1851, to July, 1852, for Galveston.

The tables from which these diagrams were made are appended to this paper, and if the detailed results should be required by any meteorologist engaged in special investigations, it will afford me pleasure to furnish them, with the consent of the Treasury Department, from the Coast Survey archives.

The same defect appears in these observations which I pointed out in those presented at the Charleston meeting, namely, that the observers tend to refer the winds to the cardinal and ordinal points mainly. The comparison of the automatic register by Osler's wind gauge, which I made formerly from the Girard College observations, showed conclusively that this was the true explanation of this apparent deficiency of winds from the intermediate rhumbs.*

A second diagram is constructed for more easy examination of the relative quantities of the several winds from month to month at these places. The ordinates are proportional to the quantity and the abscissa to the time in months from the beginning of the diagram. The headings sufficiently explain the other details.

The accuracy of the estimate of each observer may be tested if we suppose the total quantity of wind at each place to be nearly the same by the diagram for the whole year. The areas which represent the total quantity of wind in all the directions are so nearly equal as to indicate that the estimates did not differ very widely. The estimate of the force of a particular wind at Fort Morgan would appear to be the greatest, next that of Key West, and last that of Galveston. This must be borne in mind in comparing the quantities indicated for the same months at the different places.

The following remarks in reference to these results present themselves, but the generalizations lose much of their point when expressed in words. The diagrams enable the eye to seize them with ease and certainty. It is quite probable that some of these may not be exact for every year, though indicated in the result before us. The results have a direct bearing on navigation, and an incidental one on the progress of the surveying operations themselves. Commerce in this sea, closed to the westward and swept by the trade winds, must be especially indebted to steam power; the summer sea breeze along part of the coast points this out as the track for sailing vessels making to the eastward, at least along part of the coast. The current of the Gulf stream is an essential aid to the navigator of the Florida pass, constantly impeded by the prevalence of easterly winds.

The mixed character of the winds at Fort Morgan and Galveston, as distinguished from those at Key West, is instructive, when considered in reference to their positions in relation to land and water. The geographical position of these places are appropriate to the investigation of the winds of the Gulf. Key West, in latitude 24° 33′ N. and longitude 81° 48′ W., being near the eastern entrance. Fort Morgan, latitude 30° 13′ N. and longitude 88° 00′ W., near the middle of the Northern Coast of the Gulf, and Galveston, latitude 29° 18′ N. and longitude 94° 46′ W., on the Western Coast, not quite one degree north of Key West, and but half a degree further west of Fort Morgan than that position is of Key West.

The winds observed in connection with the tides at intermediate points between these, and extending the observations to the Rio Grande, will be discussed in turn.

Following the diagrams I propose, first, to trace the prevailing winds in the year; second, those in the several months and seasons and at the different places; third, the changes in quantity with the season; fourth, the varieties in direction from one season to another of winds from nearly the same quarter.

1. Winds from some northern quarter prevail from September until February, both inclusive, and southwardly winds from March to August, inclusive. Winds from the eastward prevail throughout the year, except at Fort Morgan in May, June, July, and August, when the sea breeze is from the southwest. In the whole year the winds from the same quarter north and

*The observations for Galveston are especially deficient in that respect, the observer having referred his observations to but eight points of the compass. In the diagram it was found preferable to bring the curve to zero at the intermediate points, instead of connecting the observed points, which would have increased the area disproportionally.

south balance each other nearly, while the eastwardly wind greatly predominates over the westwardly.

2. As remarked in my former paper, the months may be classed, according to the prevailing winds, into the following classes: The winter, consisting of December and January; the spring, of March and April; the summer of May, June, and July; of preparation for change August; the autumn of September, October, and November.

The winter and summer types are extremely distinct. At Key West, in December and January, northeast and north are the prevailing winds; at Fort Morgan, north, east-southeast and east; at Galveston, north and northwest, then east-northeast and southeast. I suppose the general course of the northeast trade wind to be disturbed by local action at Fort Morgan and Galveston, the local position of greatest warmth being the Gulf.

The summer type, May, June, and July, gives southeast as the prevailing wind at Key West; the southeast, south, and southwest (sea breeze) at Fort Morgan; the south, southeast, and east at Galveston, blowing towards the land.

August resembles July, with the appearance of winds which prevail in the autumn.

In September, October, and November, at Key West, east-northeast prevail; at Fort Morgan, north, northeast, east; and at Galveston, north, northeast, east, and northwest.

In March and April, the spring period, southeast, south-southeast, and east winds prevail at Key West; north, south-southeast, and east-southeast at Fort Morgan; and north, southeast, and south at Galveston.

February resembles January with a preparation for the spring period, and like August, it is characterized at Fort Morgan and Galveston by a general diminution in the quantity of wind.

January presents the full winter type of the winds on the Gulf, and June and July the full summer type. The changes are quite gradual and tolerably regular from one extreme to the other.

3. The following deductions are made from these observations in regard to the least and greatest quantities of wind in the principal directions in different portions of the year.

The north wind is a minimum at the three places in July, and a maximum in January. It is a very remarkable feature at all three places in January. The northwest almost dies out at all three from May to September, first gaining strength at Galveston, in October, and reaching its maximum in all the places in December. Its quantity at Key West and Fort Morgan is small when at the maximum.

The northers and northwesters both appear in force in April, at Galveston. There is very little west wind at either place, but more at Fort Morgan than either of the others, and chiefly during the months of June and July.

Southwest wind is of rare occurrence except at Fort Morgan, where it constitutes the sea breeze of summer, and reaches its maximum in June and July, suddenly diminishing in September.

There is but little south wind at Key West; at Fort Morgan it increases in amount in the spring and is the greatest in June. It is decidedly a marked feature as one of the prevailing spring winds at Galveston, reaching its maximum in May and becoming quite small in August, re-appearing in the winter, and rapidly increasing in March.

The northeast wind is a minimum at the three places in July and August; is largest in quantity in September, October, November, and December, at Key West; in September and October at Fort Morgan; and in September, December, and January at Galveston. The sudden increase of this wind in September, after its small quantity in August, is remarkable at all three places.

The winds intermediate between northeast and southeast occur during the changes from northeast to southeast, and it would be of little value to refer to the greatest and least quantities.

The southeast wind is a minimum in December and January at Key West; in January and February at Fort Morgan; in December and January at Galveston. It is a maximum at Key

West in July, but being replaced during the summer to a great extent by the sea breeze (S.W.) at Fort Morgan, makes its maximum in November, and at Galveston in May, doubtless from the disturbing effect of the land; it is again large in July. This is the sea breeze of Key West, and, as well as the south wind, that of Galveston.

4. The movement of the prevailing wind at Key West, where the disturbing causes of the land are the least, is very instructive.

The prevailing wind in April, May, June, and July is the southeast, hauling to the eastward in August, and becoming east-southeast. In September and October it passes further north to east-northeast, and in November and December becomes northeast; in January it reaches north; returning southward in February, it is north-northeast, in March east, and reaches the southeast in April. The local action is thus seen to prevail for the greater part of the year over the general. For the whole year the southeast wind exceeds any other from an eastwardly point.

The eastwardly wind at Fort Morgan reaches no further south than east-southeast, in the spring and summer. In September the prevailing wind is northeast passing to east-northeast in October, and back to east-southeast in the winter and spring. The general tendency for the year is then east-southeast,

The changes at Galveston resemble those at Key West, the general absence of east-northeast and east-southeast winds being due to defects in the observations.

5. Of the winds in the three localities it may be said that the southeast is the characteristic between Key West and the others; the southwest between Fort Morgan and the others; and the northwest between Galveston and the other places.

The south wind is another peculiar feature of Galveston, shared in a corresponding degree during one month only by Fort Morgan. In the prevalence of trade winds during certain months Fort Morgan and Galveston are alike.

The characteristic forms of the surface, representing the whole quantity of wind each month at Key West, is very marked. It is shared by Galveston fully only in July and August.

From May onward to September, inclusive, there appears to be little danger of northers, yet the month of June shows a considerable amount of this wind.

The velocity of the wind represented in the diagram for May, at Galveston, corresponds to 11.7 miles per hour, which is nearly the velocity for the average of the whole year.

Table of quantity and direction of wind at Key West, Florida, 1851–'52.

Months.	N.	N.N.E.	N.E.	E.N.E.	E.	E.S.E.	S.E.	S.S.E.	S.	S.S.W.	S.W.	W.S.W.	W.	W.N.W.	N.W.	N.N.W.
June	59	52	53	266	913	1086	2303	1105	338	75	110	109	20	29	56	31
July	5	43	184	103	1483	2017	3230	479	125	4	6	1	1	1	19	60
August	262	96	221	642	2398	3263	2034	988	416	19	24	1	70	204	192	135
September	169	93	766	1996	1486	538	590	209	227	191	461	173	81	132	89	128
October	213	826	2004	3179	1248	623	361	163	364	0	26	13	95	26	145	44
November	916	1443	2283	1391	1193	596	665	115	173	49	36	21	104	164	78	249
December	1271	886	2452	2220	523	344	191	207	117	134	12	13	65	92	270	406
January	2465	1365	1650	1043	177	135	133	15	53	114	141	6	49	257	402	583
February	1156	1165	1024	472	573	384	791	303	59	108	71	20	15	21	92	330
March	321	483	719	488	1505	1369	1569	927	344	90	57	137	264	591	356	189
April	484	372	158	41	349	414	832	608	586	366	235	234	238	1138	826	346
May	190	179	1206	462	852	1732	1826	160	31	13	1	0	0	0	93	113
Whole year	7306	7006	12720	12307	12699	12707	14550	5284	1936	1188	1181	728	997	2663	2526	2590

Table of quantity and direction of wind at Fort Morgan, Alabama. Mean of two years, 1847–8–9.

Months.	N.	N.N.E.	N.E.	E.N.E.	E.	E.S.E.	S.E.	S.S.E.	S.	S.S.W.	S.W.	W.S.W.	W.	W.N.W.	N.W.	N.N.W.
June	725	134	492	400	785	1095	840	243	1505	310	2242	653	702	170	192	219
July	516	73	222	112	1091	257	445	578	1049	502	2475	960	828	77	325	175
August	986	248	328	679	390	770	539	530	736	321	1577	1034	615	408	372	105
September	2725	1103	2757	1720	852	994	497	209	444	212	378	381	298	125	257	228
October	2467	1580	2155	2128	732	760	273	232	562	497	630	281	419	220	195	203
November	3141	952	871	1392	377	787	1114	621	158	34	172	151	259	65	600	566
December	1720	718	680	699	1350	1527	700	538	323	184	195	278	321	547	679	504
January	2482	683	563	898	964	1170	565	503	212	132	211	144	157	40	101	409
February	1870	814	820	721	430	699	326	605	353	199	206	434	452	66	54	720
March	1907	1282	877	477	954	1566	791	1504	923	1130	745	417	376	89	234	188
April	2086	564	616	307	651	2457	725	446	747	559	933	1096	430	107	51	466
May	1815	359	358	454	460	2127	590	598	820	1042	1933	1180	382	123	268	243
Whole year	22449	8510	10739	9987	9036	14209	7405	6607	7832	5122	11797	6731	5239	2037	3328	4026

Table of quantity and direction of wind at Galveston, Texas, 1851–'52.

Months.	N.	N.N.E.	N.E.	E.N.E.	E.	E.S.E.	S.E.	S.S.E.	S.	S.S.W.	S.W.	W.S.W.	W.	W.N.W.	N.W.	N.N.W.
July	9	3	26	319	359	992	1831	811	261	428	358	16	2	16	30	0
August	81	0	32	60	266	191	739	902	538	405	101	0	21	0	13	1
September	473	103	943	574	1639	191	417	92	180	65	121	10	85	13	10	9
October	1530	51	632	8	462	0	399	0	401	86	242	13	92	17	668	58
November	2485	128	574	0	165	0	745	125	664	114	108	28	511	104	2388	65
December	2098	0	1169	223	1612	39	475	20	189	32	195	0	300	69	2172	0
January	2764	599	1252	233	510	0	464	206	332	1	478	24	461	225	2136	17
February	531	0	771	0	657	12	997	203	613	216	535	0	106	128	744	0
March	1727	0	104	325	962	14	2297	160	1678	5	1320	82	227	0	641	612
April	1894	119	535	0	830	115	2052	319	1726	24	661	190	360	98	2186	520
May	325	17	23	0	883	430	2851	0	4047	167	277	0	192	0	132	232
June	1610	1	307	89	2315	156	644	32	1366	301	348	0	132	4	388	0
Whole year	15527	1121	6368	1831	10660	2240	13911	2870	11995	1974	4744	363	2489	674	11508	1514

APPENDIX No. 45.

Notes on the effect of the wind upon the height of water in Cat Island harbor, Mississippi, by Geo. W. Dean, Assistant United States Coast Survey, under the immediate direction of Prof. A. D. Bache, Superintendent.—(Sketch No. 39.)

WINDS.—The direction and force of the wind and the height of the water were observed hourly. The observations at Cat island were made under the direction of Lieut. Comg. C. P. Patterson, U. S. N., by Mr. Gustavus Würdemann, assisted by Mr. R. T. Bassett. The mode of observing was as follows:

A circle was marked on a piece of timber fixed firmly in the ground, and divided similar to the mariner's compass, into points and half points. In the centre of the circle was placed a small pole with a flag.

The observer in making the observations had only to notice the direction in which the flag was blown, and referring to the stationary compass, noted the direction of the wind.

The *force* of the wind was noted, according to the judgment of the observer, by a scale of numbers from 1 to 10, as in the following table:

0	Calm.
1	Light air.
2	Light breeze.
3	Moderate breeze.
4	Fresh breeze.
5	Strong breeze.
6	Fresh gale.
7	Strong gale.
8	Whole gale.
9	Storm.
10	Hurricane.

The numbers expressing force were changed to velocities by Smeaton's table, which is as follows:

Numbers.	Velocity of the wind per hour in miles.	Pressure, in pounds, on a square foot.
1	1	.005
2	4	.079
3	13	.861
4	23	2.632
5	32	5.068
6	40	7.873
7	50	12.300
8	60	17.715
9	80	31.490
10	100	49.200

Having determined the velocity of the winds for every hour the wind blew from the same direction each month, the *sum* of these velocities has been considered as the quantity of air coming from that direction during each month. The quantity of air from each direction being determined for every month in the year, diagrams (Nos. 1 to 12, Sketch No. 39) were next made for the purpose of conveying more clearly an idea (already expressed by numbers) of the quantity of air coming from each direction. These monthly results, combined according to the seasons, form a second series, (diagrams 13 to 16.) December, January, and February being grouped as the winter period, March and April as the spring period, May, June, and July as the summer, August as the period of change from summer to autumn, and September, October, and November as the autumn period. Finally, the means of the whole year are combined in diagram No. 17. From these diagrams we derive the following:

1. The prevailing winds are easterly.

2. The relative duration of easterly winds compared to the westerly winds is 2 to 1; and the average force having been determined to be the same, it follows that the quantity of air coming from the eastward is 2 to 1 compared to the quantity from the westward.

3. During December, January, and February, northeast, east, and southeast winds prevail with an excess of southeast in March and April, and of northeast (trade winds) in September, October, and November. During May, June, and July, southeast, south, and southwest winds prevail, with an excess of southwest, (sea breezes.) In August, northeast, east, southeast, and southwest winds prevail.

4. Winds from northeast, round by east and south to southwest, tend to raise the water in Cat Island harbor; and those from southwest, round by west and north to northeast, tend to depress it.

Effect of the wind to raise and depress the water.—In the discussion of the tidal observations at this station, it was advisable to ascertain, as nearly as possible, the exact influence of the winds upon the elevation and depression of the tides.

To ascertain the effect of the wind upon the tides the following method was pursued: The thirty-two points of the compass were combined so as to form but eight, (N., N. E., E., &c.) Each reading of the tide-gauge, from January 1 to August 1, was written in its appropriate column, *i.e.*, each reading of the gauge, when the wind was north, was written in the column denoted north; each reading of the gauge, when the wind was northeast, was written in the column denoted northeast, and so on for each point.

The number expressing the force of the wind was also written in its appropriate column. The mean of all the readings of the gauge, when the wind was north, has been considered as the mean height of the sea with the wind in that direction. The mean of all the readings of the gauge, when the wind was northeast, has been considered as the mean height of the sea with the wind northeast. In the same manner, the mean height of the sea has been determined when the wind was east, southeast, &c. The mean of the several heights thus determined has been considered as the mean sea level; the difference between *it* and each separate height, before determined, is the elevation or depression of the sea, caused by the winds in the several different directions.

The mean height of the water at each hour in the day, during every month, was next determined by the following method. The reading of the tide gauge at each particular hour, on every day of the month, is written on the same horizontal line, and the mean on each horizontal line is considered the average height of the tide on every day of that month corresponding to the hour found in the column on the left.

The sums of the forces of the wind for each hour in the day, for every month, and for each direction, was next determined. The sums of the forces thus found were multiplied by the number expressing the effect produced upon the tides by the wind in that particular direction. The sums of the products of the force thus found, of the winds that elevate the tides, are considered as the acting force upon the tides in one direction, and the sums of the products of the forces of the winds which depress the tides, are considered as the acting force in the *opposite direction.* This *difference* between these forces is the *total* force of the wind having a tendency to *elevate* or *depress* the tides, as the case may be. The effect produced will be directly proportional to the acting force.

If the tides produced by the sun and moon are averaged out by the process already described, the residual effect of the winds would thus be shown, and the effect being directly proportional to the impulsive force, it follows that the curve representing the height of the water at each hour will resemble the curve representing the impulsive force of the winds at the corresponding time.

The following is the mean result of hourly observations at this station, from January 1 to August 1, 1848, and shows the elevation and depression of the water in Cat Island harbor when the wind is in different directions and the average force being the same, supposing the force to the wind to be the same on the average for all the directions.—(See diagram No. 18, Skech No. 39.)

		Foot.
N.	wind depresses the water	0.24
N.E.	Do..........do	0.07
E.	Do.......elevates	0.24
S.E.	Do..........do	0.31
S.	Do..........do	0.13
S.W.	Do.......depresses	0.05
W.	Do..........do	0.12
N.W.	Do..........do	0.19
N.	Do..........do	0.24

APPENDIX No. 46.

Copy of card taken from a current bottle thrown over from the United States surveying steamer Walker, south of Mississippi delta.

UNITED STATES COAST SURVEY.

A. D. BACHE, *Superintendent.*

UNITED STATES SURVEYING STEAMER WALKER,

April 6, 1854.

Latitude.......... .... 26° 50′ N.
Longitude........................ 88° 45′ W.

The finder of this bottle will please enclose this paper to Professor A. D. Bache, Superintendent United States Coast Survey, Washington city, D. C., informing him of the time and place where found.

B. F. SANDS,
Lieutenant Commanding.

Picked up February 1, 1856, on Loggerhead key, Florida reef, by the party of Sub-Assistant C. T. Iardella.

Copy of a card contained in a current bottle thrown over near Sandy Hook, from the United States Coast Survey steamer Gallatin, Lieut. Comg. M. Woodhull, and picked up near the Bahamas.

CONSULATE OF THE UNITED STATES OF AMERICA,
Turk's Island, December 2, 1856.

SIR: I have the honor to enclose you a *current messenger* picked up on the North Caicos, and sent to a gentleman at this place, who very politely handed it to me, immediately on its reception, for transmission to the Coast Survey Office as requested.

I have the honor to be, sir, your very obedient servant,

JAMES WINTER,
United States Consul.

Prof. A. D. BACHE,
U. S. Coast Survey Office, Washington, D. C.

[No. 45.]

UNITED STATES COAST SURVEY,
October 30, 1854, 8*h*. 50*m*. A. M.

This is intended to test the currents on the coast, and the finder of this bottle will confer a great benefit to commerce and navigation if he will enclose this paper in an envelope, and direct it to Professor A. D. Bache, Superintendent Coast Survey, Washington, D. C.

Also by filling up the blank below, stating the locality, name of the shore, the day and month of finding it, and such other particulars as will aid in showing the part of the coast, and the time this bottle was found.

Where thrown overboard—United States schooner Gallatin, latitude, 40° 23′ N., longitude, 72° 53′ W.

Where picked up..	North Caicos.
Local name of beach....................................	Bottlenose creek.
Near what place..	Latitude 21° 58′ N., longitude 71° 55′ W.
In what month..	November.
On what day..	Thursday.
Date and year..	November 20, 1856.

In advance receive the thanks of the United States Coast Survey for your obliging attention to the above request.

Respectfully,

MAXWELL WOODHULL,
Lieutenant Commanding, United States Navy.

APPENDIX No. 47.

Statement of the Superintendent to the Commissioners on Harbor Encroachments, and resolution adopted by the board relative to the completion of the re-survey and maps of New York harbor and dependencies.

OFFICE OF COMMISSIONERS ON HARBOR ENCROACHMENTS,
New York, May 26, 1856.

SIR: The following operations are submitted as necessary to complete the work undertaken by the Coast Survey for the Commissioners last season, under the law and resolutions of the Commissioners and authority of the President.

1. The completion of the survey of the harbor and adjacent lands, according to the map herewith submitted.

The work of last season, and that necessary to complete the Commissioners' map, are shown in characteristic colors on the map.

2. Maps, on the scale of fifty feet to the inch, showing the water grants and the wharves and slips of New York, King's and Richmond counties.

3. Connected with these, the marking of the exterior and bulkhead lines on the maps and on the ground, and their connection with the stations of the Coast Survey to insure permanence.

4. The marking on a map, of the original shore-line, and comparative map of the city of New York at different periods.

5. The continuance of the observations at Sandy Hook to develop causes of the increase of its northern point into the main ship-channel.

The survey noted in (1) will include the completion of the hydrography of the harbor and approaches of Harlem river, Hell Gate, and the sound to Throg's neck, within the limits of the Commissioners' map approved last year.

6. The survey of the Hudson will be continued, the Overslaugh will be particularly examined, and the results be reported to the Commissioners. The progress of the tidal wave up the river will also be examined.

Should the completion of this work be directed, the parties will be assigned as they become available, and every effort will be made to complete the field-work before next winter.

Very respectfully, yours,

A. D. BACHE,
Superintendent United States Coast Survey.

Hon. G. W. PATTERSON,
President Commissioners on Harbor Encroachments, New York.

OFFICE HARBOR COMMISSIONERS,
New York, May 26, 1856.

At a meeting of the Harbor Commissioners, held this day, the following resolution was adopted:

Resolved, That the plan for the completion of the survey of the harbor, submitted by Professor Bache this day, is hereby approved.

JAMES BOWEN,
Secretary pro tem.

APPENDIX No. 48.

Report of Mr. A. Boschke, on the progress made in special topography in connection with maps of New York harbor, undertaken by the Coast Survey for the Commissioners on Harbor Encroachments.

OFFICE OF THE NEW YORK HARBOR COMMISSIONERS,
New York, October 10, 1856.

DEAR SIR: In obedience to your instructions, I proceeded to New York in May, to begin, in connection with the maps for the Commissioners on Harbor Encroachments, the revision of the detailed survey of the shores of that city and of Brooklyn and its vicinity.

A careful study of the ground, with reference to the difficulties to be overcome, showed that in organizing the parties and laying out their work so as to provide for the requisite verifications and admit of interruptions likely to occur in its progress, the lines on which the survey was to depend should be traced on the ground permanently.

The very comprehensive triangulation executed by Assistant Edmund Blunt was made the basis of my operations. New York, and the water front of Brooklyn, Williamsburg, &c., were included within a polygon well connected with this triangulation, and from it were traced base lines terminating on each wharf. These served for the survey of the wharves, by taking perpendicular offsets at intervals of twenty feet or less, as circumstances required. For the survey of the bulkheads, similar base lines were traced between adjoining wharves, from which lines, by perpendicular offsets, their position and irregularities were accurately determined. Mr. John Mechan, U. S. Coast Survey, surveyed the polygon and laid out the base lines for the wharves. Mr. O. Dietz and Mr. A. Kurth, civil engineers, were employed to measure the wharves and bulkheads. I avail myself of this opportunity to refer to the interest and carefulness evinced by these gentlemen in the discharge of their assigned duties.

The method here described was applied in the survey of New York city, from Fifty-fifth street, North river, down to the Battery, and up East river to Thirty-eighth street; and in Brooklyn, from Atlantic dock to Newtown creek. The result gave for the artificial shore-line along wharves and bulkheads on North river 17.3 miles, and on East river, on the New York side, 15.7 miles. In Brooklyn, from Atlantic dock to Newtown creek, the aggregate of artificial shore-line was 12.4 miles.

These surveys were plotted in the office, on a scale of eighty feet to an inch, and admit of showing distinctly the value of one foot in the measurements of distances on the ground.

The drawings of the wharves in position are arranged so as to be combined in an atlas 4 feet by $2\frac{1}{2}$, consisting of twenty sheets. This atlas contains also the sheets of the entire shore of New York bay and harbor, forty-five in number, on which, arranged for the series, the exterior line of the Commissioners will be laid down. A duplicate of the atlas will be made, in which, besides the exterior line, all grants made by the Commissioners will be marked for purposes of reference. The maps of the wharves will show the depth of water surrounding the piers within the slips, referred to bench-marks along the shore. In connection therewith, lines of level were run, and marked with soundings around New York city, Brooklyn, &c.

In July I made a special survey of Gowanus bay from Atlantic dock to Twenty-ninth street, terminating at "*Long dock.*" Of this survey a duplicate map has been made, drawn by Mr. Rockwell, on which the Commissioners' lines and the former grants are laid down. The map is on a scale of 200 feet to an inch—a scale sufficiently large to ascertain distances from the map within one foot.

The shores of Manhattan island from Fifty-fifth street, North river, to Spuyten Duyvel creek, including also Harlem river and Blackwell's island, and East river to Thirty-eighth street, have been surveyed and mapped on a scale of 200 feet to an inch, forming a series of ten sheets, and representing an aggregate of forty-one miles of shore-line. On these the Commissioners' line will also be represented.

A hydrographic comparative map on a scale of $\frac{1}{20000}$ is now in progress of compilation, designed to show the changes in shoals and channels within the past twenty years in New York harbor. Also a comparative map of New York city and Brooklyn, on a scale of $\frac{1}{10000}$, to exhibit the artificial changes which have been made on the North and East river fronts at different periods.

When the surveys yet in progress are completed, of the vicinity of New York bay and harbor, a general chart will be drawn on a scale of $\frac{1}{20000}$, (size of map ten feet by nine,) giving the whole of the topographical and hydrographic work, with all its characteristic details and the lines recommended by the Commissioners.

I have been fully impressed with the importance of the work entrusted to me, and have spared no pains to obtain correct results. I can say, with pleasure, that all persons connected with the duty have aided me ably and cordially in its execution.

I have the honor to be, most respectfully, yours,

A. BOSCHKE.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 49.

Report of Lieut. Comg. Stephen D. Trenchard, U. S. N., Assistant in the Coast Survey, transmitting results of the hydrographic survey of St. Simon's sound and Brunswick harbor, Ga.

FERNANDINA, EAST FLORIDA, *June* 18, 1856.

DEAR SIR: In conformity with your instructions of the 8th of January, I proceeded with the party under my charge to Brunswick, Georgia, arriving there on the 6th of February, took charge of the schooner "Bowditch," commenced hydrographic duties on the 12th of the same month, working down the river, reaching St. Simon's bar the latter part of May, and completing operations there on the 9th of June.

St. Simon's bar runs nearly north and south, is half a mile in length and less in width. Seventeen feet can be carried over it at mean low water. The general character of the bottom is coarse sand and broken shells. The compass course over the bar is about N.W., and after crossing it the channel tends two points more to the westward, running along the north breaker from a hundred to a hundred and fifty yards from it.

The channel gradually widens within the bar to near a mile.

Some two miles to the eastward of the light-house, there is a narrow shoal running east and west, with fifteen feet upon it at mean low water. The shoal is from four to five hundred yards in extent, with a channel of twenty feet upon either side of it. No other obstructions may be considered as within the channel, which is comparatively straight after crossing the *bar*, to passing the *buoy* on the sand-spit which makes out from the north point of Jekyl island. The channel then trends towards the west shore of that island until passing the buoy on the eastern point of the sand-spit or middle ground in St. Simon's sound, (*which is bare at very low tides.*) It then trends more to the southward, and quite near the *buoy* on the upper point of the middle ground which clears the extensive flat and shoal water off Jekyl creek.

The Brunswick shore is kept aboard until opening Turtle river, when the course may be shaped directly up it, carrying in more water that can be brought over the bar. From twenty-five to thirty feet water is found close in upon the Blythe island shore.

The mud flat making out from Brandy Point presents more than ten feet, being carried up to Brunswick at low water.

As regards the question whether there is less water outside of the bar than exhibited by the reconnaissance of Lieut. Comg. Craven, I would state that care was taken to determine this point, and the least water found beyond the bar was sixteen feet, about three-quarters of a mile from the outer buoy, the light-house bearing W.N.W. This was a single cast; the previous and subsequent soundings being twenty feet.

The depth of water upon the middle ground varies from eleven to fourteen feet, and the sea breaks upon it in heavy weather. A portion of the north breaker is bare at low water.

One permanent and five temporary tide-gauges were used. At the former night and day tides were observed for seventy-one days, and the results forwarded to the office.

The permanent tide station was established near the north point of Jekyl island, just within the entrance of St. Simon's sound. The mean rise and fall of ordinary tides is about six and a half feet, and spring tides about seven and a half feet.

Ten current stations were occupied. The greatest velocity of the tide was found off Jekyl, near the tide station, during full moon; it was running from five to six miles per hour, and its ordinary velocity is from two and a half to three miles.

On the bar, the flood sets W.N.W., and the ebb E.S.E., one and a half miles per hour.

It is high water at Brunswick twenty-four minutes later than at St. Simon's entrance, and low water twenty-eight minutes later.

I would respectfully recommend that a buoy be placed upon the shoal already mentioned, and one also upon the outer point of the south breaker. In the execution of the hydrographic duty of St. Simon's sound and Brunswick harbor, five hundred and ninety-eight (598) miles of soundings were run; twenty-eight thousand two hundred (28,200) casts of the lead made; eighteen hundred and fifty-six (1,856) theodolite, and three hundred and eighteen (318) sextant angles observed.

All of which is respectfully submitted by your obedient servant,

STEPHEN D. TRENCHARD,

Lieut. Comg. U. S. N., Assistant U. S. Coast Survey.

Prof. A. D. BACHE,

Superintendent Coast Survey, Washington, D. C.

APPENDIX No. 50.

Correspondence in relation to the capacity and character of the harbor of Fernandina, Florida.

OFFICE OF THE BOARD OF UNDERWRITERS,
New York, August 6, 1856.

Some inquiries have been made of our underwriters as to the rate of premium to be charged to the *incipient* port of Fernandina, Florida, and we are referred to thee for information relative to the harbor, from which we may form an opinion as to the risks to be incurred, compared with other southern Atlantic ports.

If not trespassing too much on thy valuable time, we should be glad to hear from thee in relation to this matter.

Respectfully, thy friend,

ELLWOOD WALTER,
Secretary Board of Underwriters.

Professor A. D. BACHE,
Superintendent Coast Survey, Washington.

COAST SURVEY OFFICE, *August* 15, 1856.

SIR: I have the honor to acknowledge the receipt of your letter of August 6, making inquiries in regard to the harbor of Fernandina.

This harbor was surveyed in a preliminary way by the Coast Survey in 1855, and again more completely this year. It is easy of entrance, and has good anchoring ground after passing within the bar. The harbor of Fernandina is completely landlocked, and has good holding ground in deep water. There is 6½ fathoms in the channel off the railroad company's wharf.

Fourteen feet can be carried at mean low water over the bar, the channel being from one-sixteenth to one-fourth of a mile wide. The channel, though changing its position in a period of years, retains its depth. The mean rise and fall of the tide is 6 feet, and at spring the rise and fall is about 7 feet.

The bar can be crossed in two courses, and there are no special dangers inside of it. There is a light-house on Amelia island, and there are buoys for marking the entrance.

These facts show that this harbor compares very favorably with others on the southern coast.

Yours, respectfully,

A. D. BACHE,
Superintendent U. S. Coast Survey.

ELLWOOD WALTER, Esq.,
Secretary Board of Underwriters, New York.

APPENDIX No. 51.

Extracts from the report of Assistant A. M. Harrison, with local details of the topographical survey of the shores of St. John's river, Florida.

UNITED STATES COAST SURVEY SCHOONER "BENJAMIN PEIRCE,"
Off Jacksonville, Florida, February 8, 1856.

SIR: By express I forward to you three topographical sheets, embracing the survey of the St. John's river, from Mayport Mills to Winter's Point, above Jacksonville. The mouth of the

St. John's, and part of the outer shore was surveyed by Sub-Assistant R. M. Bache in 1853. My work joins his at Mayport Mills. The topographical survey executed by myself, includes the shore-line of both banks of the St. John's, the filling in, inland, of from a quarter to half a mile, and the complete survey of all the islands and bars bare at low water in the river.

The character of the country embraced in the limits of the first sheet of St. John's river, extending from Mayport Mills to Brown's creek, is marshy, intersected by numerous creeks and sloughs, which empty into the river at frequent intervals. In many places, at irregular distances back from the river, are isolated hammocks of fast land, covered with pines and palmettoes. At one point only upon this sheet does the fast land reach the river. St. John's Bluff is the extremity of a range of wooded hills, jutting upon the river at a bend of a few miles above Mayport Mills, forming an abrupt bluff, composed of sand and clay about forty feet high. Several marsh islands and a few sand bars, bare at low water, are embraced in this sheet.

The second sheet, extending from Brown's creek to Point Suarrez, embraces the widest portion of the river between the entrance and Jacksonville. The shores gradually change their character in ascending, and after passing Dame's Point, they are, for the most part, covered with pines, presenting occasional slight elevations in the interior, and bluffs at the water's edge. There are a few plantations, but none of importance. There are several marsh islands extending as far as Newcastle, (an old plantation of some prominence,) Crab island, about the middle of the sheet, being the last one that is found as far up the river as the survey extends. Mill Cove, a large shallow bend in the river, is bordered by a narrow strip of marsh, backed by a thick growth of pines, water-oaks, and a few palmettoes. The extremity of Dame's Point is irregularly wooded, while the marsh extends through back of it, from the shore above the point, to the shore below it, and in cases of very heavy freshets, it is sometimes overflowed sufficiently to allow the passage of boats of very light draught. This, however, is rarely the case. Three important creeks empty into the river on this sheet—namely, Dunn's, Cedar, and Trout creeks—the mouth of the latter being situated directly opposite to Reddie's Point, at the angle of an abrupt bend of the St. John's.

The third and last sheet extends from Point Suarrez to Winter's Point, above Jacksonville, the southern shore being occasionally somewhat hilly, and the northern nearly level. The banks are much wooded, and in some places abrupt. There is but little marsh, and considerable cultivation. A few small creeks empty into the river on this sheet, and one rather prominent one, named Pottsburg creek, but there are no islands.

The St. John's, between its entrance and Winter's Point, has seven bends, namely, at Mayport Mills, St. John's Bluff, Mill Cove Point, Dame's Point, Reddie's Point, Commodore's Point, and just above Jacksonville, its general direction being N.E. Changes are slowly but continually going on in the banks and islands of the river. I am informed by General B. Hopkins, for some years the proprietor of the plantation at St. John's Bluff, that that bluff, where the river impinges against the shore with the full force of its current, is washed away annually to the extent of about four feet. At Yellow Bluff, the bank wears away at an average of three feet a year, above the ordinary water line; but there is very little change observable in the shore immediately below it. At Yellow Bluff, Dame's Point, and, in fact, all the bluffs along the river, ordinarily the washing is unimportant; but during the prevalence of N.E. and S.E. gales, or heavy freshets, it is more strongly felt.

One marsh island to the eastward of St. John's Bluff has been formed within ten years past. No trace of Quarantine island existed nineteen years since, and I am told that since the year 1828 most of the islands in the river have been so augmented or changed, as to present but little resemblance to their configuration or size previous to that date.

It has been proposed by those who have investigated the subject, that, by closing the mouths of the streams which flow into the St. John's, near its entrance, which are supposed to operate against the stability of the present depth of water on the bar, (owing to a counteraction of tides, producing an accumulation of sand,) there would result a concentration of the current of the river sufficiently strong to increase the amount of water on the bar, or at any rate maintain it at its present depth.

* * * * * * * * * * *

Very respectfully, your obedient servant,

A. M. HARRISON,
Assistant.

Prof. A. D. Bache,
Superintendent U. S. Coast Survey, Washington, D. C.

APPENDIX No. 52.

Report to the Commissioner of the General Land Office, showing the progress made during the season in the survey and marking of the Florida Keys.

Coast Survey Office, *October* 14, 1856.

Sir: In continuation of the work on the Florida keys, prosecuted for the General Land Office by the Coast Survey, I have the honor to communicate the progress of the two triangulation and two plane-table parties which have been engaged in it, and copies of the reports of the two topographical parties, for the past season.

As a basis for the plane-table work, the triangulation of the keys, since the date of my last report, has been extended eastward from Johnston's key and Point Dora, and terminated at the close of the season at stations in Jacob's harbor, a distance of thirty-two miles from Johnston's key. Between these limits the positions of twenty-seven intervening keys, lying within an area of about three hundred and forty-eight square miles, have been determined.

The report of Sub-Assistant Iardella will be found to contain remarks on the general character of the keys surveyed by his party, and the details of the method employed in marking the land sections. His topographical sheet, copies of which are herewith transmitted in triplicate, and on the scale $\frac{1}{10000}$, as required for the purposes of the General Land Office, includes a part of Sugar Loaf key, Cudjoe key, Loggerhead key, Summerland's key, Gopher key, and several smaller keys, not known by any local designations.

I forward also, in triplicate, copies of the topographical sheet of Sub-Assistant Wainwright, containing the survey of Johnston's key, Sawyer's key, and numerous smaller keys in their immediate vicinity.

His report accompanying describes the local features of the keys upon which his party were employed.

The two topographical sheets of this season present a surveyed area of thirty-six square miles within two hundred and sixty-three miles of shore-line determined by the parties.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. Thos. A. Hendricks,
Commissioner General Land Office.

Washington, D. C., *June* 10, 1856.

Sir: * * * * * * * * * * * * * * * *

My topographical sheet of the season comprises Johnston's and Sawyer's keys, two other large keys, and thirty-five small ones, surrounded by immense banks. The work lies between 34° 41½′ and 34° 45½′ N. lat., and 81° 33½′ to 81° 38½′ W. long., embracing thirty miles of shore-line of keys, fifty-three miles of bank, and three or four square miles of interior.

Johnston's key, the principal one of these keys, is a mile and a half long and three quarters of a mile wide, in the widest part, covered with high and low mangrove and buttonwood. This key is the only one in the vicinity that has any considerable amount of fast land on it, the greater part of it being intersected by a lagoon. It has about half a square mile of fast land, with a thin coating of soil, and the usual coral rock bottom, though it produces fine looking trees and bushes in the interior. This key seems to have been the nucleus from which a large number of small keys have formed almost all around it, and connected with it, by large banks, which spread from two and a half to three miles to the westward, and one to the northward, covered with these small mangrove keys.

Between the westernmost chain there run channels some four feet deep. At a short distance there does not appear to be more than nine or ten of these little keys, but they are divided up into twenty-four or twenty-five, being nothing more than mangrove clumps overhanging the water which flows through them.

Sawyer's key, the next in size, and the only other one designated by a local name, is about one and three-quarter mile long, and not over one-quarter of a mile wide. From the water it appears to be quite a large key; but from the small key on which the signal stands there is a coral bank extending one mile in length up to the main key. This is interspersed with small bushes, and covered with water at high tide, and only separated from the bay, on the northern side of the key, by a strip of bank from eleven to twenty-two yards wide, which runs from the western point of the key all around the outside of it, and is the only fast land on it.

The next key in size lies to the northward and westward of Johnston's key. Though about a mile long, and one quarter wide, it is nothing more than a coral bank with clumps of mangrove here and there. All the smaller keys are of the same character, being merely clumps of mangroves surrounded by coral banks. The largest of them is but little over 200 yards long and 100 wide.

Johnston's key is the only one on which I thought it would be at all useful to put up section posts for the Land Office, as there is land on it which I think might be cultivated, but not in any large body. The other keys are without value at present for that purpose.

Ten iron stakes, flattened at the top and marked with the letters U. S. C. S. on one side, and M. or P. on the other, were placed on Johnston's key, the sections being laid off from either side of the middle meridian and parallel.

Respectfully,

S. A. WAINWRIGHT,

Sub-Assistant Coast Survey.

Prof. A. D. Bache,

Superintendent U. S. Coast Survey.

Washington City, D. C., *June* 20, 1856.

Sir: In pursuance of your instructions, I repaired to Key West in November, but owing to the delay of the United States schooner Joseph Henry, the commencement of my work was retarded until the 1st of January.

The operations of the party for this year embraced a portion of Sugarloaf key, lying about twenty miles northward and eastward from Key West, Cudjoe key, extending several miles further in the same direction, Loggerhead key, and Summerland's key. Several smaller keys were also included, situated between Loggerhead and Cudjoe, and around the shores of Summerland, Cudjoe, and Sugarloaf.

Sugarloaf key, part of which was surveyed the preceding season, is about ten miles in length by six in breadth, thus covering near fifty square miles.

This tolerably extensive area is reduced more than one-half by the numerous sounds, all connected with each other, that fill up its interior. The depth of water in these bays varies from three or four feet to as many inches. The shore extending from Sugarloaf signal towards Martha signal is generally sandy up to the limits of the tide, where a belt of long grass separates it from the fringe of woods that stretches along its whole length. Beyond Martha signal, for a distance of three miles, the rocky foundation of the key is left bare until nearly opposite Eliza signal, where a dense growth of mangrove bushes borders the shore as far as Happy Jack's plantation. The shore then again becomes rocky till it changes into extensive mud flats around Point Dora signal, where several narrow openings lead into the interior sound. Besides these entrances there are two creeks at opposite extremities of the sound. The broader, though not the longer of the two, serves as its outlet, near Sugarloaf signal. It is about one mile long, with a very uniform breadth. The other, which comes out about $\frac{3}{4}$ mile below Martha signal, is $1\frac{1}{4}$ mile in length, and extremely narrow, hardly allowing a boat to pass in some places. Through this inconvenient and winding creek almost all of the interior work had to be finished, which materially retarded its progress. The tide runs with great force here, as it is almost the only passage in this direction for the immense sheet of water confined within the key.

The surface of Sugarloaf is almost a dead level, covered in some places with forests of mangrove, button-wood, and various less important trees; in others, extending into flat plains, carpeted with a short wiry grass, and dotted here and there with mangrove bushes or single trees. The soil is usually far from good, though, around Happy Jack's, it supports various tropical fruits, and produces excellent sweet potatoes. This key is marked by sixty-four posts, parallel, meridianal, and at intersections of the quarter-section lines. The rocky foundation of the key is marked by iron stakes, $2\frac{1}{2}$ feet long, driven into the coral rock four or five inches; they are marked on one side with a cold chisel—the other side with black paint; also by cedar posts, four feet long, driven into the ground two feet, and protected by coral rocks piled around them. The cedar posts are marked on one side with the letters U. S. C. S., and on the other side M. MP. or P. with black paint.

Cudjoe key, which lies next to Sugarloaf, in a N.E. direction, is entirely separated from it by a channel about four miles in length, with a depth varying from two to six feet. It is irregular in shape, and about $4\frac{1}{2}$ miles in one direction by 3 miles in another. The shore of Cudjoe is generally rocky, except towards its northern extremity, which is bounded by extensive mud flats and several small keys, almost entirely covered by the sea at high tide. Like Sugarloaf, it is filled with lagoons, though these are neither so numerous or so deep. They have seldom any connection with each other; and at very low tide, become dry in many places. A belt of mangrove forests almost entirely surrounds Cudjoe, and clumps of trees are scattered throughout its interior. A line of pine trees runs from Johnson's plantation almost across the key, and may be seen from almost any part of the coast.

There is some very good land on Cudjoe, though it would hardly repay cultivation, except in a few spots. Cudjoe key is marked with 24 posts, iron and cedar, in the same manner as Sugarloaf and Summerland's.

Summerland's key, which is separated from Cudjoe by a channel, much resembling that between Sugarloaf and Cudjoe, bears a striking resemblance to the last in shape and quality of the land. It is not so large, being $3\frac{1}{4}$ miles long by $1\frac{1}{2}$ mile wide. The shore, like Cudjoe's, is rocky, except towards the N.W., where it is cut up into a great variety of small keys and mud flats, and filled with lagoons. Near Palmetto signal there is a forest of palmettoes, which gradually gives place to the usual growth of mangrove. A few families have made a settlement near the shore, just opposite Ramrod signal, where the land is tolerably good. Elsewhere, it is generally worthless. A small mangrove key lies not far from this settlement; and between this and Loggerhead we found three small grassy keys, with hardly a dozen trees upon them. There are also two small keys, about $\frac{1}{4}$ mile from Cudjoe, towards Loggerhead, which form the centre of an extensive shoal, almost blocking up the passage between them and Cudjoe's. This key is marked with 25 posts, iron, cedar, and yellow pine, the same as Sugarloaf.

Loggerhead is a long narrow key about two miles from Cudjoe. It is one mile long by $\frac{1}{4}$ mile in breadth. Its shore is sandy and bordered with trees, while its opposite side is hidden by mangrove bushes, which grow far into the water. A thick forest of mangrove and button-wood extends from the signal through its whole length. This key is marked with four cedar posts.

Gopher is a small key partially covered with mangrove, lying between Loggerhead and Cudjoe.

My season's work of five months closed on May 28, and covers an area of seventy square miles, including water, the actual area of ground is about 32 square miles, and 210 miles of shore line. Mr. F. W. Alexander assisted me in the work, for which great credit is due him.

I have the honor to be, very respectfully, your obedient servant,

C. T. IARDELLA,
Sub-Assistant U. S. Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 53.

Extracts from the report of Assistant A. M. Harrison, relative to the local characteristics of the western coast of Florida adjacent to Cedar Keys.

U. S. SCHOONER "BENJAMIN PEIRCE,"
Perth Amboy, N. J., June 30, 1856.

SIR: * * * * * * * * * * *

As regards the nature of the country over which my surveys of this season extended the general characteristics are as follows:

The main shore consists of a strip of marsh about a mile wide, generally overflowed by high tides, and backed by pine and palmetto forests. The water is very shoal for a great distance seaward, and is filled with oyster reefs, which in some places (as at Cedar Keys, and at Waccasassa bay, and southward) are exposed more or less, according to the tides.

The following are the general features of those rivers, the mouths of which have been examined:

Waccasassa river.—This is quite a narrow stream, flowing into Waccasassa bay, some miles to the east of Cedar Keys. The entrance is filled with oyster reefs, affording a narrow boat channel only, with not over a foot of water at low tide. Flats, however, can be employed. The mouth is marshy, cut up by bayous. A mile or so back commence the woods, consisting of irregular palmetto hammocks, with some cedars.

We-thlocco-chee river, a few miles south of the Waccasassa, is marshy at the entrance, and has, likewise, many oyster bars at its mouth. It is not navigable for vessels drawing over three feet of water. Inside, however, there is a greater depth. There are two entrances, the southern one only being available. About two miles from the mouth the woods and bushes overhang the bank.

Crystal river, still further to the south, is much wider than the We-thlocco-chee, and the banks are firmer around the mouth. It has two entrances, (the southern one being the widest and deepest,) formed by Shell island, which is the highest land found along the main shore for some distance, being about 25 feet above high-water mark. Off the mouth are several lines of oyster reefs, running nearly parallel, and more or less bare, depending on the tides. Vessels drawing ten feet of water can anchor with safety inside the first oyster reef, the entrance being marked by a pole on the port hand going in.

There are a number of vessels employed in getting cedar at the Crystal river. It is obtained about five miles up, and rafted down to vessels at anchor inside the oyster reef.

Homosassa river.—This stream, a few miles below the Crystal river, empties into the Gulf of Mexico a mile or so below the upper end of St. Martin's reef, and its mouth is marked by two prominent live-oak trees on a shell bank at the southern side, and a large rock projecting from the water a short distance to the north. A wreck lies stranded on the outer shore, not far below. There are numerous branches near the mouth, forming a marshy delta, but the proper channel is staked out.

Vessels drawing five feet water can ascend the river as far as the plantation of Senator Yulee. Nine feet can be carried nearly up to the entrance between the reefs.

Very respectfully submitted.

A. M. HARRISON,
Assistant U. S. Coast Survey.

Professor A. D. BACHE,
Superintendent U. S. Coast Survey, Washington.

APPENDIX No. 54.

Letter to the Superintendent from Lieut. Comg. John K. Duer, U. S. N., Assistant in the Coast Survey, with recommendations for entering the harbor of Crystal river, western coast of Florida.

U. S. SURVEYING SCHOONER VARINA,
Key West, Florida, June 20, 1856.

SIR: Circumstances of recent occurrence, relating to the delay and loss of time of vessels upon their arrival off Crystal River harbor, have induced me to make the suggestion given below.

Pilots are not to be procured there, and it is extremely hazardous for any stranger bound to that harbor to attempt to enter by any directions he may have received.

It would, therefore, be the better plan for commanders of vessels bound to Crystal River harbor to shape their course directly for Cedar Keys, and on making the light-house on Sea-Horse Key, and getting the proper bearing on, (N. by E. per compass,) run in to between two and three miles of the shore, and make signals for a pilot. One can be procured here thoroughly acquainted with all the localities in the vicinity.

On arriving at night off Sea-Horse key, it would be safe to run for the light, but not to approach nearer than three miles, and keeping on the bearing as above, anchor in three fathoms, if the weather be good, or, at all events, with the wind off shore.

I remain, sir, very respectfully, your obedient servant,

JOHN K. DUER,
Lieut. Com'g U. S. N., Assistant Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey, Washington, D. C.

APPENDIX No. 55.

Extracts from reports made to the Superintendent, under dates June 18 and 20, by Sub-Assistant Spencer C. McCorkle, relative to the capacity of the harbors of St. Mark's and Apalachicola, Florida.

St. Mark's.—The importance of this harbor, in my opinion, rests solely upon the fact that it is the seaport of Tallahassee, from which is exported from forty to fifty thousand bales of cotton annually. The depth of water in the channel can doubtless be increased without a great outlay, the obstructions being oyster bars and sand stone rocks, all of which will be fully demonstrated in the hydrographic survey since made.

Apalachicola.—This harbor possesses advantages over all others between Key West and Pensacola, by being the outlet of the Chattahoochee river, which is navigable nearly four hundred miles, and from which have been exported, during the present season, nearly 100,000 bales of cotton. The trade will be eventually increased by large shipments of lumber, which abounds in the upper river; and also from the fact that there is 16½ feet of water over the bar at East Pass, and 12½ at West Pass at low water, and a secure anchorage of three or four fathoms inside. On the northern shore, opposite East Pass, a point of land called Topsail Bluff can be approached within three hundred feet with a depth of water of fourteen feet, and this point is now occupying attention as the proposed terminus of several railroads. The channels through the sound can be improved, and I am of the opinion that, after a hydrographic survey, the harbor will be found of more importance and occupy more attention than at present. The prevalence of hurricanes has had a bad effect upon all parts of this coast, but there is reason to suppose that they will not occur so frequently, at least for some years to come.

Very respectfully, yours, &c., &c.,

SPENCER C. McCORKLE,
Sub-Assistant.

Prof. A. D. BACHE,
Superintendent Coast Survey, Washington, D. C.

APPENDIX No. 56.

Extract from a report of Assistant J. E. Hilgard to the Superintendent, on the progress of the triangulation in Mississippi sound and Lake Borgne.

WASHINGTON, *January* 20, 1856.

DEAR SIR: * * * * * * * *

Signals and station-marks.—1. The signal I used with most success is simply a whitewashed board from six to ten feet long, and from eight to fourteen inches wide, set up on top of the tripod, or where greater height was requisite, nailed to the top of a pole, and facing so as to have a good illumination on it at usual times of observation. Nothing can show better or afford easier pointing. It fails, however, when the station to be observed is nearly to the south—except in midsummer, when a morning and evening illumination is had even then. In such cases I used the revolving reflectors with good effect. The whitewashed boards were principally used in the primary triangulation, when it was not thought to be taking too much pains to shift their direction and centering as different stations were occupied.

Another form of signal that I found very efficient is made in the following manner: about four feet from the top of a pole two holes are bored at right angles, into which sticks are driven projecting about one foot on each side. From the end of these to the top of the pole laths are nailed, and common muslin is stretched over them and tacked down, forming a four-sided pyramid, which shows very well, and, although subject to phase, always presents a central apex.

Insignificant as these details appear, I communicate them as being of practical value, the expedients being inexpensive and very effective.

2. The marking of stations has received special attention. The means employed varied with circumstances, natural marks of reference being preferred. As an ultimate station mark, buried below the surface beyond the reach of accidental or even wilful disturbance, the stoneware cone, introduced by Mr. Hassler, has been generally used by me, and I consider it very suitable for the purpose.

As marks on the surface of the ground, marble and granite blocks have been used, the centre block being always of different material or shape from the surrounding ones, which were placed at certain distances, either in the cardinal points of the horizon or in other well marked directions. There are localities where marks of this kind can hardly be expected to be preserved from the effects of wind and sea in extraordinary storms, and where there are no trees or other natural marks of reference. Where the latter existed, additional reference has been made to them.

I refer to my station book for the modes employed in each particular case, but will instance two cases to show how they have been varied according to circumstances.

On the sandhill at Cat island it has hitherto not been found feasible to secure the station point, owing to the shifting nature of the sand, which at one time leaves the marks entirely denuded, allowing them to fall over or slide, at another time covers them up to the depth of six or eight feet. Since 1847, the highest part of the hill has moved about fifty yards to the westward. Besides marking the station by a granite block at the bottom of a long square box of wood, sunk vertically into the sand, points were permanently marked in a clump of pine trees to the north, and in a live oak copse to the west, each distant about 500 metres; and the angles at these points to the station on the hill were measured, by means of which the latter may at any time be replaced by an intersection.

At Pitcher Point the station is necessarily on the beach, and liable to destruction. Marble blocks were buried in the woods at distances of fifty and one hundred feet, and in the direction from Cat island sandhill, which is a very prominent object.

The localities offering the greatest difficulties in the way of preserving the stations are those in the marsh about the lakes and bayous of the Mississippi river. In many instances the stations are necessarily near the water's edge, where a narrow belt of broken shells offers some stability; the surface marks are liable to be covered up, or the whole bank is washed away, or the stones are removed by fishermen, as convenient ballast for boats. There are frequently no natural marks whatever by which to identify the locality approximately.

As an attempt for their better preservation, I have put down iron screw-piles at some of the most important points on Lake Borgne—not at the station points themselves, but in the marsh behind the shell ridge, carefully noting distance and direction. These screw piles are sunk 3½ feet, and project about eighteen inches; they are very difficult to remove, and will escape observation from being in the marsh, where they are also more secure from the effects of the sea. They will probably last a long time, and it may be worth while to replace them before they are entirely destroyed by oxydation. They were cast by Hayward, Bartlett & Co., of Baltimore, and cost less than six dollars each, including transportation.

Very respectfully, yours,

J. E. HILGARD.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 57.

Letter of Commander James Alden, U. S. N., Assistant Coast Survey, transmitting a communication from H. A. Goldsborough, Esq., in relation to the resources of Washington Territory.

UNITED STATES COAST SURVEY STEAMER ACTIVE,
San Francisco, December 4, 1856.

DEAR SIR: I enclose a letter received a few days since from an old resident of Washington Territory, H. A. Goldsborough, Esq. You will, I trust, find the information he gives of great use in forming an estimate of the value of that interesting country.

With great respect, I am, very truly, JAMES ALDEN,
Commander U. S. N., Assistant Coast Survey.

Prof. A. D. BACHE,
Supdt. Coast Survey.

OLYMPIA, WASHINGTON TERRITORY, *October* 1, 1855.

MY DEAR SIR: In reply to your request that I would give you information in regard to the trade of the various places, their facilities of commerce, supplies of lumber, coal, &c., &c., in this Territory, I take great pleasure in complying, and in giving you the results of my observation and experience in these respects.

From the entrance of the Straits of Fuca, some two hundred miles, to this place, which is the southern extremity of Puget Sound, we have about twelve hundred miles of internal coast navigation, suitable for vessels of any description, and indented with numerous safe inlets, bays, and harbors, the shores of which are covered with magnificent and inexhaustible forests, principally of fir and cedar, with some ash, maple, oak, &c. Owing to the great facility of procuring lumber, that has been the largest article of our export; and immense quantities of sawed lumber, piles, spars, and shingles, have been shipped hence to the markets of California, Sandwich Islands, Australia and China. The shipments of piling have very sensibly decreased within the last eighteen months, owing principally to the circumstance, that the objects for which they were required have measurably been accomplished in the extension of the immense wharves of San Francisco and other neighboring ports, while the manufacture of sawed lumber has very greatly increased from the year 1850 to the present time, with diminished prices at this date, attributable to the late heavy failures in the monetary transactions of the principal receiving port of California. In 1850 there was but one saw mill north of the Columbia, situated near Olympia, at the head of Budd inlet, owned and built by Colonel M. S. Simmons, and of capacity to supply say certainly three thousand feet per day. This was the amount of sawed lumber that could be obtained throughout the Puget Sound district on the 1st of January, 1851. At the present writing we have—

Near Olympia, 4 sawmills, making	13,000	feet per day.
In Henderson's inlet, 1 sawmill	2,500	"
In Hammersley's inlet, 1 sawmill	3,500	"
At Nisqually, 2 sawmills	6,000	"
At Steilacoom, 1 sawmill	4,000	"
At Veryallup, 1 sawmill	3,500	"
At Seattle, 1 sawmill	5,000	"
Port Orchard, 1 sawmill	12,000	"
Port Gamble, 1 sawmill	20,000	"
Port Ludlow, 2 sawmills	12,000	"
Bellingham bay, 1 sawmill	3,500	"

I have put these mills down at their lowest ordinary capacity, capable of an increase, under exigencies, of 20 per cent. There being now wharves at Seattle, Port Orchard, and Port Gamble, lumber at present is more easily obtained at these points than at the other places mentioned; but this difficulty will be early remedied; and as they all afford safe anchorages, their choice may, in general terms, be said to depend upon their respective distances from the ocean, and their available capacities for supplying the wants of commerce. The very low price of lumber, the great stagnation in trade, and the heavy failures in San Francisco within the last twenty months have very materially depressed our lumber business; but it is capable of a rapid and almost indefinite enlargement, should the wants of commerce on the coast to the southward, or across the ocean to Japan, Australia, China, &c., authorize it. Before long, too, this country must necessarily be looked to for immense supplies of spar timber, for which it is peculiarly adapted, and of which the great points of previous supplies are becoming rapidly deficient.

The only points from which coal has heretofore been exported are Bellingham bay and the Duwamish river. Both of these places are very accessible, and should the coal from either or both prove good, the supply will be found, from present appearances, almost inexhaustible. Upon this subject, however, I have long been of opinion that the best coal existing in the Puget Sound district of country is to be found near the sources of some of the rivers flowing westerly from the Cascades. I would refer more especially to the Stoluckguamish, which empties into Possession Sound at the foot of McDonogh's island, and some twenty miles up, at which point I know there exists coal in abundance. A specimen of it, examined by Professor Johnson, of Washington, was pronounced by him to be the best specimen of American cannel coal he had then (1851) seen.

By removing two large "drifts," which now obstruct the navigation of this stream, or by altering its channel so as to avoid them, coal could readily be transported in large scows from the fields to a good harbor at its mouth. Excellent coal also abounds in Vancouver's island, and the extension of the "reciprocity treaty" to the British possessions on the northwest would probably render this coal available on moderate terms, so as to insure an ample supply for any number of steamers that might connect our sound with the ports of the eastern ocean.

* * * * * * * * * * *

The waters of our sound and vicinity contain large quantities of the salmon, cod, halibut, &c., and afford most desirable facilities as entrepôts for our whaling fleets cruising to the eastward, and between the parallels of 50° and 60° north latitude, and 140° to 150° of west longitude. The Sandwich Islands are now the general rendezvous for this whaling fleet for supplies of provisions, spars, &c.; but should they turn their attention to our waters, they would save fifteen to twenty days in distance, find a better harbor, say Port Townshend or Seattle, and get their supplies better and cheaper. In point of fact, the vicinity of Cape Flattery itself is no despicable whaling ground, if one may judge from the ascertained fact that, in 1852, the few Indians residing in that neighborhood, with the crude means in their possession, without kettles or any other facilities, except of their own contrivance, and with light cedar canoes, actually caught whales enough to enable them to sell 30,000 gallons of oil, which brought in the market of San Francisco $1 50 to $1 80 per gallon.

Within the past three months considerable excitement has been created in our midst by the discovery of *gold* on Clarke's fork of the Columbia river, a few miles above Fort Colville. These mines have not yet been thoroughly examined. The first wild and exaggerated reports caused eager and excited crowds to rush thither without a sufficiency of provisions and other essentials to test the value and accessibility of the mines; but the recent murders committed by the Yakima tribe of Indians, and the present intense alarm consequent thereon, soon compelled the almost utter desertion of this gold region until the abatement or entire cessation of the Indian disturbances. I have understood from gentlemen who have visited the district solely with the view of ascertaining carefully its auriferous merits, that these mines are not adapted to individual ill-provided efforts, but will require skill, labor, and capital, and when thus worked, they may be expected to yield immense profits. It is to be hoped that such will turn out to be the exact state of the case, as transient, ill-directed, and worse appropriated gatherings of gold, can never be of that permanent benefit to a country which always results from the concentration of skill, capital, and enterprise, in the same undertaking. Access to these mines from our waters may be had by tapping the Cascades either at the Naa-ches or Sno-qual-moo passes. The latter is decidedly preferable. It is barometrically some 2,300 feet lower than the former, in a more direct line with the northern trail from St. Paul's, Minnesota. It avoids all the difficult crossings of White river, a confluent of the Duwamish, and was the chosen route of Governor Stevens in his explorations for a northern line of railroad. It is within 55 miles of Seattle, a promising town near the mouth of the Duwamish, possessing the finest and largest body of agricultural land and the best harbor in the whole district. An adequate appropriation by Congress for a military or territorial road from Fort Benton on the Missouri, via the Sno-qual-moo pass to Seattle on Puget Sound, would be of more positive and permanent benefit to this section of country than any other single measure I now know of, as it would greatly facilitate immigration and render comparatively easy the transport of troops and supplies through a country nearly coterminous with Great Britain's possessions, and inhabited by tribes of Indians over whom the *protection* and the *power* of our government should be brought into efficient exercise without delay.

Washington Territory, notwithstanding its great and universally acknowledged salubrity, its soil perfectly adapted to the culture of all the cereals except maize, its valuable forests and ample waters, has not very sensibly increased in population within the past two years. This fact may be attributed to various causes, its remoteness from the populous eastern States, the difficulty at present of reaching it, and its propinquity to the *golden* State of California, whither all our migratory citizens rush, anxious apparently to spend a lifetime in search of a gilded shadow. There is another reason, however, for this sparseness of population, which I think has not been duly considered, although it has exercised a very serious influence. I allude to our donation laws. * * * * * * Business, trade, enterprise, and capital will seek and find their proper level. They cannot be safely forced.

The law of September, 1850, gave 640 acres of land to every married, and half of that quantity to every unmarried, citizen who would reside upon and cultivate the same for four consecutive years, without power, however, of alienation over these unnecessarily large tracts during this long period of probation. Under these circumstances men of enterprise and capital would not come here, when they could purchase public land to the eastward at the minimum price, and have the benefit of four years' speculation thereon if they desired it. * *

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I look forward to the 1st of December proximo, when the donation law expires by limitation, as the harbinger of a new and better state of things. The lands should be surveyed as fast as possible and thrown at once into market, then we will see capital and all its attendant advantages flowing gradually but surely towards this delightful country.

Truly, your friend,

H. A. GOLDSBOROUGH.

Commander JAMES ALDEN, U. S. N.,
Assistant Coast Survey.

APPENDIX No. 58.

Table for projecting maps of large extent, arranged by Assistant J. E. Hilgard.

The tables are based on a polyconic development of the earth's surface, which supposes each parallel of latitude represented on a plane by the development of a cone having the parallel for its base, and its vertex in the point where a tangent to the parallel intersects the earth's axis. The degrees on the parallel preserve their true length, and the general distortion of area is less than in any other mode of representing a given portion of the earth's surface.

Denoting by a the equatorial radius of the spheroid, e the eccentricity, then the normal to any point on the parallel of latitude L, is $\mathrm{N} = \frac{a}{(1 - e^2 \sin^2 \mathrm{L})^{\frac{1}{2}}}$. The radius of the parallel $\mathrm{R}p = \mathrm{N} \cos \mathrm{L}$; and the radius of the developed parallel, or the side of the tangent cone $r = \mathrm{N} \cot \mathrm{L}$. Designating by n any arc of the parallel, or difference of longitude to be developed, and by θ the corresponding angle subtended by the developed parallel at the vertex of the cone, then the length of the given arc will be

$$n\,\mathrm{R}p = n\,\mathrm{N} \cos \mathrm{L},$$

and also $\theta r = \theta\,\mathrm{N} \cot \mathrm{L}$; and hence $\theta = n \sin \mathrm{L}$.

To determine rectangular co-ordinates X and Y, for projecting from the middle meridian the points of intersection of the meridians and parallels, we have simply, the developed parallels being arcs of circles,

$$\mathrm{X} = r \sin \theta, \qquad \mathrm{Y} = r \operatorname{versin} \theta.$$

Table I gives the co-ordinates for thirty degrees of longitude on each parallel, from latitude 20° to 54°. The numbers correspond to the actual dimensions of the earth in metres, and are to be divided by the proper number for any desired scale.

Table II gives the length, in metres, of one degree of latitude and longitude, for each degree of latitude, from 20° to 54°; also the radii of the developed parallels, which may be used to describe the parallels by means of beam-compasses, when the scale permits. It also gives the values of θ for 10° of longitude, by means of which the tables may readily be extended.

In order to project a map by the aid of these tables, draw a straight line as middle meridian of the map, on which space off the required degrees of latitude by the values given in Table II. Through the points so marked construct lines perpendicular to the meridian, and parallel with each other, which will be tangents to the parallels of latitude at their intersection with the middle meridian.

On these tangents lay off, from the middle meridian, for each required longitude the corresponding X from the tables, and offset Y perpendicular to it, to the northward. Through the points so found, draw continuous curves for the parallels and meridians.

Tables III, IV, and V are auxiliaries for converting metres into yards and miles, and reciprocally, to accommodate the values in the preceding tables to other units. It will, however, be obvious to every experienced draughtsman, that, in place of making a great many numerical conversions, it will be preferable, in every case in which the scale used is not a simple fraction of the natural size—such as one-millionth part or one ten-millionth part of nature—to draw a scale so divided and numbered that the values from the tables can be immediately taken off. For instance, if it is required to project a map on a scale of 50 miles to 1 inch, we find in Table III. B., that 50 miles are equal to 80,470 metres; we construct a scale, therefore, on which 1 inch is called 80,470 metres, or we make 1.2427*in.* = 100,000 metres, and with this scale work from the Tables of X and Y, with unchanged numbers.

When the polyconic development is extended to the whole surface of the sphere, a figure results, which is represented on Sketch No. 65. The distortion, unavoidable in any representation of a spherical surface on a plane, is here greatest in the equatorial regions near the eastern and western extremities of the map. The circumpolar regions are well represented, and it is believed that this projection will be found preferable to Mercator's for maps illustrating various points of physical geography, the only kind for which representations of the whole sphere are likely to be desirable.

Table VI gives the data for the projection of a sphere on this principle. Draw the central meridian from pole to pole = 3.142, the radius of the sphere being assumed = 1. On this meridian space off every tenth degree of latitude, and, through the points so obtained, describe the parallels with the corresponding radii from the table, and construct their limits by the co-ordinates x and y. On each parallel, space off equidistant meridians with the values of 10° of parallel given in the table, and, through the points so determined, draw (with a curve board or piece of whalebone) continuous curves for the meridians. In the projection of a hemisphere the limiting line differs but little from a circle, as will be perceived by tracing out the meridian 90° East and West on the map. While this mode of representing a hemisphere is undoubtedly the best that can be devised for preservation of areas and azimuths, the following modification approaches to it so nearly, and is so simple in its construction, that it deserves particular notice.

The radius of the sphere being assumed = 1, with a radius of 1.571 describe a circle as limiting line, and draw diameters for equator and central meridian; describe each parallel with a radius equal to the cotangent of the latitude, as given in Table VI, and divide them into equal parts for the intersections of meridians.

This is, in fact, a method in common use, and although empirical in its nature, that is to say, not representing any geometrical idea of projection or development, it varies from the very best method by quantities quite inconsiderable where the representation necessarily deviates very far from nature.

The following constants may be found useful:

Equatorial radius of earth	$a =$	6377397 metres:	log. = 6.80464346
Polar radius of earth	$b =$	6356079 "	" = 6.80318928
Square of the eccentricity	$\frac{a^2 - b^2}{a^2} = e^2 =$	0.00667437	" = 7.8244104

1 metre = 39.36850 inches of the United States standard scale.

TABLE I.

Table of co-ordinates for projecting the points of intersection of meridians and parallels.

Longitude.	Latitude 20°.		Latitude 21°.		Latitude 22°.		Latitude 23°.		Latitude 24°.		Latitude 25°.		Longitude.
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	
°	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	°
1	104,634	312	103,958	325	103.249	337	102,510	348	101,737	361	100,938	372	1
2	209,265	1,249	207,911	1,300	206,494	1,350	205,014	1,398	203,472	1,444	201,866	1.489	2
3	313,888	2,810	311,856	2,926	309,730	3,038	307,510	3.146	305.196	3,250	302,790	3,350	3
4	418,499	4,997	415,790	5,201	412,953	5,400	40[illegible]	5,592	406,905	5,777	403,694	5,956	4
5	523,096	7,807	519,706	8.127	516,158	8,437	512,453	8,737	508,592	9,027	504,577	9,305	5
6	627,674	11,242	623,603	11,703	619,341	12,149	614 893	12,581	610,254	12,999	605,432	13,399	6
7	732,231	15,300	727,475	15,928	722,498	16,536	717,301	17,124	711,885	17,691	706,253	18,237	7
8	836,758	19,984	831,319	20,803	825,623	21,597	819.677	22,365	813,481	23,106	807,037	23,818	8
9	941,260	25,291	935,130	26,327	928,714	27,332	922,016	28,304	915.036	29,241	907,777	30,142	9
10	1,045,727	31,221	1,038,905	32,501	1,031,765	33,740	1,024,310	34,938	1,016,543	36,097	1,008,467	37,209	10
11	1,150,156	37,775	1,142,639	39,323	1,134,771	40.823	1,126,558	42,274	1,118,003	43,673	1,109,102	45.019	11
12	1.254.544	44,952	1,246,327	46,794	1,237,729	48,579	1,228,753	50,305	1,219.404	51,970	1,209,677	53,571	12
13	1,358,888	52,753	1,349,968	54,915	1,340,634	57,008	1,330,892	59,033	1,320,740	60,986	1,310,187	62,864	13
14	1,463,182	61,176	1,453,556	63,682	1,443,482	66,110	1,432,968	68.457	1,422,013	70,721	1,410,624	72,899	14
15	1,567.426	70,221	1,557,087	73,097	1,546,268	75,883	1,534,977	78,577	1.523,217	81,175	1,510,986	83,673	15
16	1,671,613	79,888	1,660,556	83,160	1,648,989	86,329	1,636,915	89,393	1,624,339	92,347	1,611,266	95,189	16
17	1,775,740	90,178	1,763,962	93,869	1,751,638	97,446	1,738.777	100,903	1,725,381	104,237	1.711,456	107,443	17
18	1,879,804	101,089	1,867,297	105,226	1,854,214	109,233	1,840.559	113,108	1,826,337	116,844	1,811,555	120,436	18
19	1,983,802	112,620	1,970,560	117,228	1,956,708	121,695	1,942,254	126,006	1,927,200	130,166	1,911,554	134,168	19
20	2,087,729	124,772	2,073,746	129,876	2,059,120	134,820	2,043,860	139,598	2,027,967	144,205	2,011,450	148.636	20
21	2,191,580	137,545	2,176,855	143,169	2,161,446	148,617	2,145,370	153,882	2,128,631	158,959	2,111,235	163,840	21
22	2,295,355	150,937	2,279,871	157,107	2,263,676	163,083	2,246,779	168,859	2,229,188	174,431	2,210,908	179,781	22
23	2,399,047	164,949	2,382,802	171,689	2,365,815	178,216	2,348,086	184,526	2,329,632	190,608	2,310,458	196,456	23
24	2,502,654	179,578	2,485,639	186,914	2,467,844	194,019	2,449,282	200,885	2,429,959	207,503	2,409,884	213.865	24
25	2,606,172	194,827	2,588,378	202,782	2,569,772	210.487	2,550,365	217,932	2,530,164	225,108	2,509,178	232,007	25
26	2,709,596	210,692	2,691,017	219,294	2,671,591	227.621	2,651,329	235,669	2,630,241	243,425	2,608,336	250,880	26
27	2,812,925	227,176	2,793,550	236.445	2,773,294	245,421	2,752,169	254,094	2,730,186	262,452	2,707,352	270,485	27
28	2,916,151	244,275	2,895,973	254,239	2,874,881	263,885	2,852,883	273,205	2,829,993	282,187	2,806,220	290,819	28
29	3,019,276	261,991	2,998,285	272,672	2,976,343	283,013	2,953,462	293,004	2,929,657	302,631	2,904,936	311,882	29
30	3,122,294	280,321	3,100,478	291,745	3,077,677	302,805	3,053,906	313,488	3,029,174	323,781	3,003,493	333,672	30

TABLE I—Continued.

Longitude.	Latitude 26°.		Latitude 27°.		Latitude 28°.		Latitude 29°.		Latitude 30°.		Latitude 31°.		Longitude.
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	
°	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*M tres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	°
1	100,105	383	99,242	393	98,349	403	97,426	412	96,474	421	95,491	429	1
2	200,204	1,532	198,478	1,573	196,692	1,612	194,845	1,649	192,940	1,684	190,975	1,717	2
3	300,291	3,446	297,702	3,538	295,021	3,626	292,250	3,709	289,391	3,788	286,444	3,862	3
4	400,361	6,127	396,907	6,290	393,330	6,446	389,635	6,594	385,821	6,735	381,889	6,866	4
5	500,407	9,573	496,086	9,828	491,614	10,072	486,991	10,303	482,221	10,522	477,304	10,728	5
6	600,424	13,784	595.235	14,152	589,864	14,503	584,313	14,836	578,585	15,151	572,680	15,447	6
7	700,406	18,760	694,346	19,260	688,074	19,738	681,593	20,192	674,904	20.620	668,010	21,024	7
8	800,347	24,501	793,414	25,155	786,238	25,778	778,824	26,370	771,172	26,930	763,285	27.457	8
9	900,241	31,007	892,431	31,835	884,350	32,623	875,999	33,372	867,381	34,080	858,499	34,747	9
10	1,000,083	38,277	991,392	39,298	982.402	40,271	973,111	41,194	963,524	42,068	953,644	42,891	10
11	1,099,865	46,310	1,090,293	47,545	1,080,388	48,722	1,070,153	49,839	1,059,594	50,896	1,048,712	51,891	11
12	1,199,583	55,107	1,189,124	56,576	1,178,302	57,976	1,167,120	59,305	1,155,583	60,562	1,143,694	61,744	12
13	1,299,232	64,666	1,287,881	66,389	1,276,136	68,031	1,264,003	69,590	1,251,484	71,064	1,238,584	72,452	13
14	1,398,804	74,988	1,386,556	76,985	1.373,886	78,888	1,360,795	80,695	1,347,290	82,404	1,333,375	84,012	14
15	1,498,296	86,070	1,485,145	88,362	1,471,542	90,546	1,457,490	92,619	1.442,994	94,579	1,428,057	96,423	15
16	1.597,697	97,914	1,583,640	100,520	1,569,100	103,003	1,554,080	105,360	1.538,587	107,588	1,522,625	109,685	16
17	1,697,006	110,518	1,682,036	113,458	1,666,552	116,259	1,650 559	118,918	1,634,063	121,432	1,617,069	123,797	17
18	1,796,215	123,882	1,780,326	127,175	1,763,893	130,313	1,746,920	133,292	1,729,415	136,108	1,711,382	138,757	18
19	1,895,320	138,004	1,878,505	141,672	1,861,115	145.165	1,843,156	148,481	1,824,635	154,615	1,805,557	154,564	19
20	1,994,313	152,884	1,976,565	156,944	1,958,212	160,812	1,939,260	164,484	1,919,715	167,953	1,899,587	171,217	20
21	2,093,191	168,521	2,074,502	172,994	2,055,178	177,255	2,035,225	181,300	2,014,650	185,120	1,993,463	188,715	21
22	2,191,946	184,914	2,172,308	189,819	2,152,005	194,492	2,131,044	198,925	2.109,432	203,115	2,087,177	207,056	22
23	2,290,571	202,061	2,269,978	207,419	2,248,689	212,521	2,226,710	217,362	2,204,053	221,936	2,180,723	226,238	23
24	2,389,063	219,963	2,367,505	225,791	2,345,221	231,342	2,322,218	236,608	2,298,506	241,583	2,274,093	246,261	24
25	2,487,415	238,619	2,464,884	244,937	2,441,596	250,953	2,417,558	256,661	2,392,784	262,052	2,367,279	267,122	25
26	2.585,622	258,026	2,562,108	264,853	2,537.807	271,354	2,512,727	277,520	2,486.879	283,345	2,460.273	288,819	26
27	2,683,677	278,184	2,659,172	285,539	2,633,848	292,541	2,607,715	299,183	2,580,786	305,456	2,553,070	311,352	27
28	2,781,575	299,092	2,756,067	306,993	2,729,711	314,516	2,702.516	321,649	2,674.496	328,387	2,645,660	334,719	28
29	2,879,310	320,749	2,852,791	329,214	2,825,392	337,275	2,797,124	344,918	2,768,001	352,134	2,738,036	358,916	29
30	2,976,877	343,150	2,949,335	352,201	2,920,883	360,817	2,891,631	368,985	2,861,297	376,697	2,830,192	383,943	30

TABLE I—Continued.

Longitude.	Latitude 32°.		Latitude 33°.		Latitude 34°.		Latitude 35°.		Latitude 36°.		Latitude 37°.		Longitude.
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	
°	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	°
1	94,480	437	93,441	444	92,373	451	91,276	457	90,151	462	88,999	467	1
2	188,953	1,748	186,873	1,776	184,736	1,803	182,542	1,827	180,293	1,850	177,989	1,869	2
3	283,410	3,932	280,288	3,997	277,082	4,057	273,791	4,112	270,416	4,161	266,959	4,206	3
4	377,842	6,990	373,678	7,105	369,401	7,211	365,011	7,309	360,510	7,398	355,899	7,477	4
5	472,241	10,921	467,034	11,101	461,685	11,267	456,196	11,419	450,567	11,558	444,800	11,681	5
6	566,601	15,725	560,349	15,984	553,926	16,223	547,334	16,443	540,576	16,642	533,653	16,821	6
7	660,911	21,402	653,612	21,754	646,113	22,079	638,418	22,378	630,528	22,649	622,446	22,893	7
8	755,166	27,950	746,817	28,410	738,240	28,835	729,438	29,225	720,414	29,579	711,171	29,897	8
9	849,355	35,370	839,954	35,952	830,295	36,488	820,384	36,982	810,224	37,430	799,817	37,833	9
10	943,472	43,661	933,014	44,378	922,272	45,041	911,249	45,650	899,949	46,202	888,374	46,699	10
11	1,037,509	52,822	1,025,991	53,689	1,014,160	54,491	1,002,022	55,226	989,579	55,895	976,834	56,495	11
12	1,131,456	62,853	1,118,875	63,884	1,105,953	64,837	1,092,695	65,711	1,079,104	66,506	1,065,186	67,219	12
13	1,225,308	73,751	1,211,658	74,960	1,197,640	76,079	1,183,258	77,104	1,168,517	78,035	1,153,421	78,870	13
14	1,319,054	85,517	1,304,331	86,919	1,289,213	88,214	1,273,703	89,402	1,257,806	90,480	1,241,529	91,449	14
15	1,412,687	98,150	1,396,887	99,757	1,380,663	101,243	1,364,019	102,605	1,346,963	103,842	1,329,499	104,952	15
16	1,506,199	111,648	1,489,317	113,475	1,471,982	115,163	1,454,200	116,711	1,435,979	118,117	1,417,322	119,377	16
17	1,599,583	126,011	1,581,611	128,071	1,563,160	129,975	1,544,234	131,720	1,524,842	133,304	1,504,990	134,725	17
18	1,692,829	141,237	1,673,763	143,544	1,654,189	145,675	1,634,114	147,628	1,613,546	149,402	1,592,491	150,993	18
19	1,785,932	157,324	1,765,763	159,893	1,745,061	162,263	1,723,830	164,437	1,702,080	166,409	1,679,817	168,179	19
20	1,878,880	174,272	1,857,605	177,113	1,835,766	179,738	1,813,373	182,142	1,790,434	184,324	1,766,957	186,281	20
21	1,971,669	192,078	1,949,278	195,206	1,926,297	198,096	1,902,735	200,741	1,878,600	203,144	1,853,902	205,297	21
22	2,064,289	210,742	2,040,775	214,171	2,016,644	217,337	1,991,905	220,237	1,966,569	222,868	1,940,643	225,225	22
23	2,156,733	230,263	2,132,087	234,004	2,106,800	237,459	2,080,877	240,623	2,054,330	243,492	2,027,170	246,064	23
24	2,248,991	250,637	2,223,208	254,704	2,196,754	258,460	2,169,640	261,899	2,141,876	265,017	2,113,472	267,810	24
25	2,341,058	271,863	2,314,126	276,270	2,286,499	280,338	2,258,185	284,062	2,229,196	287,438	2,199,543	290,461	25
26	2,432,923	293,940	2,404,836	298,699	2,376,026	303,091	2,346,503	307,110	2,316,281	310,754	2,285,370	314,015	26
27	2,524,579	316,866	2,495,329	321,989	2,465,328	326,717	2,434,588	331,042	2,403,123	334,961	2,370,945	338,470	27
28	2,616,020	340,638	2,585,597	346,138	2,554,394	351,212	2,522,428	355,854	2,489,711	360,059	2,456,258	363,822	28
29	2,707,241	365,256	2,675,630	371,144	2.643,217	376,576	2,610,014	381,544	2,576,038	386,043	2,541,301	390,068	29
30	2,798,228	390,715	2,765,423	397,009	2,731,788	402,806	2,697,341	408,110	2,662,093	412,912	2,626,063	417,207	30

TABLE I—Continued.

Longitude.	Latitude 38°.		Latitude 39°.		Latitude 40°.		Latitude 41°.		Latitude 42°.		Latitude 43°.		Longitude.
	X	Y	X	Y	X		X	Y	X	Y	X	Y	
°	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	°
1	87,820	472	86,614	476	85,382	479	84,123	481	82,839	484	81,529	485	1
2	175,630	1,887	173,218	1,903	170,753	1,916	168,235	1,926	165,666	1,935	163,047	1,941	2
3	263,420	4,246	259,801	4,281	256,103	4,310	252,326	4,334	248,471	4,353	244,541	4,367	3
4	351,180	7,548	346,352	7,610	341,420	7,662	336,382	7,705	331,243	7,738	326,001	7,762	4
5	438,899	11,793	432,862	11,889	426,695	11,971	420,395	12,038	413,969	12,090	407,415	12,127	5
6	526,567	16,980	519,320	17,118	511,915	17,236	504,353	17,332	496,638	17,407	488,771	17,461	6
7	614,174	23,109	605,715	23,297	597,071	23,456	588,245	23,587	579,240	23,690	570,058	23,763	7
8	701,710	30,179	692,037	30,424	682,153	30,632	672,060	30,803	661,762	30,936	651,264	31,032	8
9	789,166	38,189	778,275	38,499	767,147	38,762	755,786	38,978	744,195	39,146	732,378	39,267	9
10	876,630	47,138	864,419	47,520	852,045	47,845	839,414	48,111	826,526	48,317	813,387	48,466	10
11	963,793	57,026	950,460	57,487	936,837	57,879	922,931	58,200	908,744	58,451	894,282	58,630	11
12	1,050,945	67,850	1,036,385	68,399	1,021,510	68,865	1,006,327	69,246	990,839	69,541	975,050	69,755	12
13	1,137,976	79,611	1,122,186	80,254	1,106,055	80,799	1,089,591	81,246	1,072,798	81,593	1,055,680	81,841	13
14	1,224,875	92,306	1,207,851	93,050	1,190,461	93,681	1,172,713	94,198	1,154,610	94,600	1,136,160	94,887	14
15	1,311,633	105,934	1,293,371	106,787	1,274,717	107,509	1,255,680	108,101	1,236,266	108,561	1,216,479	108,889	15
16	1,398,239	120,493	1,378,733	121,462	1,358,813	122,282	1,338,484	122,953	1,317,753	123,475	1,296,627	123,846	16
17	1,484,684	135,982	1,463,931	137,073	1,442,738	137,997	1,421,111	138,753	1,399,060	139,339	1,376,590	139,756	17
18	1,570,957	152,400	1,548,951	153,620	1,526,481	154,653	1,503,552	155,497	1,480,176	156,152	1,456,357	156,616	18
19	1,657,049	169,742	1,633,784	171,099	1,610,031	172,247	1,585,796	173,184	1,561,090	173,911	1,535,920	174,425	19
20	1,742,950	188,010	1,718,421	189,509	1,693,379	190,777	1,667,833	191,812	1,641,791	192,614	1,615,264	193,180	20
21	1,828,650	207,199	1,802,850	208,848	1,776,514	210,241	1,749,651	211,378	1,722,270	212,258	1,694,380	212,877	21
22	1,914,138	227,308	1,887,062	229,112	1,859,426	230,637	1,831,238	231,880	1,802,512	232,840	1,773,254	233,516	22
23	1,999,405	248,334	1,970,045	250,301	1,942,103	251,961	1,912,587	253,314	1,882,509	254,358	1,851,878	255,091	23
24	2,084,442	270,275	2,054,791	272,410	2,024,537	274,212	1,993,684	275,679	1,962,249	276,809	1,930,240	277,602	24
25	2,169,237	293,129	2,138,290	295,439	2,106,714	297,386	2,074,520	298,970	2,041,721	300,189	2,008,328	301,042	25
26	2,253,782	316,893	2,221,530	319,382	2,188,627	321,481	2,155,084	323,186	2,120,915	324,496	2,086,132	325,410	26
27	2,338,068	341,564	2,304,504	344,239	2,270,264	346,492	2,235,366	348,322	2,199,820	349,727	2,163,640	350,703	27
28	2,422,083	367,138	2,387,197	370,005	2,351,617	372,418	2,315,354	374,376	2,278,425	375,877	2,240,841	376,917	28
29	2,505,819	393,615	2,469,603	396,678	2,432,673	399,256	2,395,038	401,344	2,356,718	402,943	2,317,726	404,048	29
30	2,589,264	420,989	2,551,712	424,258	2,513,422	427,000	2,474,408	429,223	2,434,691	430,921	2,394,281	432,092	30

TABLE I—Continued.

Longitude.	Latitude 44°		Latitude 45°		Latitude 46°		Latitude 47°		Latitude 48°		Latitude 49°		Longitude.
	X	Y	X		X	Y	X	Y	X	Y	X	Y	
°	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	°
1	80,194	486	78,835	486	77,452	486	76,045	485	74,614	484	73,161	482	1
2	160,377	1,944	157.659	1,946	154,892	1,945	152,077	1,941	149,216	1,935	146,309	1,927	2
3	240,536	4,375	236,458	4,378	232,307	4,375	228,085	4,368	223,792	4,354	219,432	4,336	3
4	320,660	7,777	315,221	7,782	309,685	7,778	304,055	7,764	298,331	7,740	292,516	7,708	4
5	400,737	12,150	393,936	12,158	387,015	12,152	379,976	12,130	372,820	12,093	365,550	12,042	5
6	480,754	17,494	472,591	17,505	464,284	17,495	455,835	17,464	447,246	17,411	438,521	17,338	6
7	560,702	23,807	551,175	23,823	541,480	23,809	531,619	23,766	521,597	23,695	511.415	23,594	7
8	640,566	31,089	629,674	31,109	618,590	31,091	607,317	31,035	595,860	30,942	584,220	30,810	8
9	720,337	39,339	708,078	39,364	695,603	39.341	682,916	39,270	670,022	39,151	656,925	38,985	9
10	800,001	48,556	786,373	48,586	772,506	48,557	758,404	48,469	744.073	48,322	729,515	48,116	10
11	879,549	58,737	864,549	58,774	849,287	58,738	833,768	58,631	817,997	58,452	801,979	58,203	11
12	958,967	69,883	942,594	69,925	925,935	69,882	908,997	69,754	891,784	69,541	874,303	69,243	12
13	1,038,243	81,990	1,020.495	82,039	1,002,437	81,987	984,077	81,836	965,421	81,584	946,476	81,235	13
14	1,117,367	95,058	1,098,239	95,113	1,078,780	95,052	1,058,997	94,876	1,038,896	94,584	1,018,485	94,177	14
15	1,196,327	109,084	1,175,817	109,145	1,154,953	109,074	1,133,745	108,871	1,112,197	108,534	1,090,317	108,065	15
16	1,275,112	124,066	1,253,215	124,134	1,230,945	124,053	1,208,307	123,819	1,185,309	123,434	1,161,959	122,899	16
17	1,353,708	140,002	1,330,423	140,077	1,306,742	139,982	1,282,673	139,717	1,258,223	139,281	1,233,401	138,676	17
18	1,432,106	156,890	1,407,428	156,972	1,382,334	156,863	1,356,830	156,563	1,330,925	156,072	1,304,628	155,392	18
19	1,510,294	174,727	1,484,219	174,816	1,457,707	174,691	1,430,766	174,354	1,403,403	173,805	1,375,629	173,044	19
20	1,588,258	193,511	1,560,784	193,605	1,532,851	193,465	1,504,467	193,088	1,475,645	192,476	1.446,391	191,631	20
21	1,665,990	213,238	1,637,111	213,339	1,607,754	213,180	1,577,926	212,761	1,547,639	212,083	1,516,902	211,147	21
22	1,743,477	233,907	1,713,189	234,013	1,682,402	233,834	1,651,126	233,370	1,619,372	232,622	1,587,150	231,591	22
23	1,820,708	255,514	1,789,006	255,624	1,756,786	255,423	1,724,058	254,912	1,690,833	254,090	1,657,123	252,958	23
24	1,897,670	278,055	1,864,550	278,169	1,830,893	277,945	1,796,708	277,382	1,762,009	276,482	1,726,808	275,246	24
25	1,974,355	301,527	1,939,811	301,645	1,904,711	301,395	1,869,066	300,779	1.832,889	299,796	1,796,193	298,449	25
26	2,050,748	325,928	2,014,775	326,048	1,978,228	325,770	1,941,119	325,097	1,903,461	324,027	1,865.267	322,564	26
27	2,126,840	351,253	2,089,434	351,373	2,051,435	351,067	2,012,856	350,382	1,973,712	349,172	1,934,017	347,587	27
28	2,202,620	377,498	2,163,773	377,619	2,124,317	377,280	2,084,265	376,481	2,043,631	375,225	2,002,432	373.513	28
29	2,278,076	404,661	2,237,784	404,780	2,196,866	404,406	2,155,335	403,540	2,113,207	402,183	2,070,500	400,338	29
30	2,353,197	432,736	2,311,449	432,852	2,269,067	432,441	2,226,052	431,504	2,182,427	430,042	2,138,207	428,058	30

TABLE I—Continued.

Longitude.	Latitude 50°.		Latitude 51°.		Latitude 52°.		Latitude 53°.		Latitude 54°.		Longitude.
	X	Y	X	Y	X	Y	X	Y	X	Y	
°	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	*Metres.*	°
1	71,685	479	70,186	476	68,667	472	67,127	468	65,567	463	1
2	143,357	1,917	140,360	1,904	137.322	1,888	134,241	1,871	131,117	1,851	2
3	215,003	4,312	210.510	4,284	205,950	4,249	201,329	4,210	196,645	4,165	3
4	286,611	7,666	280.618	7,614	274,541	7.553	268,378	7.483	262,131	7,404	4
5	358,168	11,976	350,676	11,896	343,078	11,801	335,375	11.692	327,566	11,567	5
6	429,661	17,243	420,671	17,126	411,549	16.990	402,304	16,832	392,937	16,654	6
7	501,077	23,465	490,586	23,307	479,946	23,120	469,157	22,906	458,226	22,664	7
8	572,403	30,641	560,411	30,434	548,249	30,192	535,920	29,911	523,427	29,595	8
9	643,627	38,771	630,133	38,510	616,451	38,202	602,576	37,845	588,521	37.445	9
10	714,736	47,851	699,742	47,530	684,534	47,146	669,119	46,707	653.500	46,212	10
11	785,718	57,882	769,219	57,490	752,487	57,030	735,530	56,498	718,347	55,899	11
12	856.558	68,861	838,555	68,398	820,300	67,845	801,798	67,215	783,052	66,497	12
13	927,246	80,786	907,736	80,240	887,956	79,592	867,910	78,850	847,602	78,010	13
14	997,768	93,655	976,753	93,020	955,446	92,270	933,854	91,407	911,980	90,431	14
15	1,068,111	107,465	1,045,588	106,733	1,022,753	105,873	999,614	104,880	976,178	103,765	15
16	1,138,264	122,215	1,114,230	121,382	1,089,866	120.401	1,065,180	119,274	1,040,184	118.002	16
17	1,208,213	137,902	1,182,670	136,963	1.156,777	135.850	1,130,540	134,578	1,103,977	133,140	17
18	1,277,946	154,522	1,250,890	153,465	1,223,466	152,219	1,195,684	150,791	1,167,554	149,178	18
19	1,347,451	172,073	1,318,880	170,893	1,289,926	169,504	1,260,594	167,908	1,230,894	166,110	19
20	1.416,715	190,552	1,386,627	189,240	1,356,139	187,699	1,325,260	185,930	1,293,993	183,936	20
21	1,485,725	209,955	1,454,119	208,503	1,422,035	206,804	1,389,665	204,853	1,356,834	202,650	21
22	1,554,471	230,279	1,521,346	228,686	1,487,785	226,818	1,453,800	224,670	1,419,401	222,250	22
23	1,622,938	251,520	1,588,290	249.775	1,553,192	247,726	1,517,653	245,381	1,481,688	242,732	23
24	1,691,115	273,675	1,654,943	271,771	1,618.307	269,540	1,581,213	266,977	1,543,671	264,092	24
25	1,758,990	296,739	1,721,292	294,670	1,683,114	292,242	1,644,465	289,457	1,605 360	286,323	25
26	1,826,550	320,709	1,787,322	318,465	1,747,603	315,836	1,707,398	312,820	1,666,725	309,430	26
27	1,893,784	345,580	1,853,027	343.153	1,811,762	340,312	1,769,999	337,055	1,727,754	333,393	27
28	1,960,680	371,347	1,918,390	368,730	1,875,577	365,669	1,832,256	362,163	1.788,440	358,218	28
29	2,027,224	398,006	1,983,398	395,193	1,939,040	391,900	1,894,155	388,131	1,848,761	383,897	29
30	2,093,407	425,553	2,048,043	422,532	2,002,133	418,984	1,955,688	414,965	1,908,730	410,425	30

TABLE II.

Length, in metres, of one degree of latitude and longitude, from latitude 20° to 54°; values of the corresponding radii of the developed parallel, and angles at each pole for 10° of longitude.

Lat.	1° of latitude.	1° of longitude.	Radius of parallel.	θ for 10° of longitude.
°	*Metres.*	*Metres.*	*Metres.*	° ′ ″
20	110 693.3	104 634.8	17 528 600	3 25 12.7
21	110 706.0	103 958.2	16 620 820	35 01.3
22	110 719.2	103 250.0	15 792 110	44 45.8
23	110 732.9	102 510.5	15 031 865	54 26.3
24	110 747.1	101 739.8	14 331 780	4 04 02.5
25	110 761.7	100 938.2	13 684 530	13 34.3
26	110 776.7	100 105.9	13 083 990	23 01.4
27	110 792.2	99 243.2	12 524 960	32 23.7
28	110 808.1	98 350.2	12 002 960	41 41.0
29	110 824.4	97 427.4	11 524 770	50 53.1
30	110 841.0	96 474.8	11 055 200	5 00 00.0
31	110 858.0	95 492.9	10 623 179	09 01.4
32	110 875.2	94 481.9	10 215 570	17 57.1
33	110 892.8	93 442.1	9 830 067	26 47.0
34	110 910.7	92 373.8	9 464 760	35 31.0
35	110 928.8	91 277.3	9 117 882	44 08.8
36	110 947.2	90 152.9	8 787 972	52 40.3
37	110 965.8	89 001.0	8 473 340	6 01 05.3
38	110 984.6	87 821.9	8 173 042	09 23.8
39	111 003.5	86 616.0	7 885 875	17 35.5
40	111 022.6	85 383.6	7 610 788	25 40.4
41	111 041.8	84 125.1	7 346 915	33 38.1
42	111 061.1	82 840.8	7 093 423	41 28.7
43	111 080.5	81 531.1	6 849 560	49 11.9
44	111 100.0	80 196.5	6 614 648	56 47.7
45	111 119.4	78 837.3	6 388 064	7 04 15.8
46	111 138.9	77 453.9	6 169 244	11 36.2
47	111 158.4	76 046.8	5 957 663	18 48.7
48	111 177.8	74 616.3	5 752 845	25 53.2
49	111 197.2	73 162.9	5 554 355	32 49.6
50	111 216.4	71 687.0	5 361 781	39 37.6
51	111 235.6	70 189.1	5 174 752	46 17.3
52	111 254.6	68 669.6	4 992 925	52 48.4
53	111 273.4	67 129.0	4 815 973	59 10.9
54	111 292.1	65 567.7	4 643 603	8 05 24.6

TABLE III.—A.

Table for converting metres into statute miles.

1 metre = 0.000621346 mile.

[6.7933335.]

Metres.	Miles.	Metres.	Miles.	Metres.	Miles.	Metres.	Miles.
100000	62.135						
90000	55.921	9000	5.592	900	.559	90	.056
80000	49.708	8000	4.971	800	.497	80	.050
70000	43.494	7000	4.349	700	.435	70	.044
60000	37.281	6000	3.728	600	.373	60	.037
50000	31.067	5000	3.107	500	.311	50	.031
40000	24.854	4000	2.485	400	.249	40	.025
30000	18.640	3000	1.864	300	.186	30	.019
20000	12.427	2000	1.243	200	.124	20	.012
10000	6.213	1000	.621	100	.062	10	.006

TABLE III.—B.

Table for converting statute miles into metres.

1 mile = 1609.40831 metres.

[3.2066665.]

Miles.	Metres.	Miles.	Metres.	Miles.	Metres.	Miles.	Metres.
100	160940.83						
90	144846.75	9	14484.68	0.9	1448.47	0.09	144.85
80	128752.66	8	12875.27	0.8	1287.53	0.08	128.75
70	112658.58	7	11265.86	0.7	1126.59	0.07	112.66
60	96564.50	6	9656.45	0.6	965.65	0.06	96.56
50	80470.41	5	8047.04	0.5	804.70	0.05	80.47
40	64376.33	4	6437.63	0.4	643.76	0.04	64.38
30	48282.25	3	4828.23	0.3	482.82	0.03	48.28
20	32188.17	2	3218.82	0.2	321.88	0.02	32.19
10	16094.08	1	1609.41	0.1	160.94	0.01	16.09

TABLE III.—C.

Table for converting metres into yards.

1 metre = 1.09356959 yard.

[0.0388464.]

Metres.	Yards.	Metres.	Yards.	Metres.	Yards.	Metres.	Yards.	Metres.	Yards.
100000	109356.96								
90000	98421.26	9000	9842.13	900	984.21	90	98.42	9	9.84
80000	87485.57	8000	8748.56	800	874.86	80	87.49	8	8.75
70000	76549.87	7000	7654.99	700	765.50	70	76.55	7	7.65
60000	65614.18	6000	6561.42	600	656.14	60	65.61	6	6.56
50000	54678.48	5000	5467.85	500	546.79	50	54.68	5	5.47
40000	43742.78	4000	4374.28	400	437.43	40	43.74	4	4.37
30000	32807.09	3000	3280.71	300	328.07	30	32.81	3	3.28
20000	21871.39	2000	2187.14	200	218.71	20	21.87	2	2.19
10000	10935.70	1000	1093.57	100	109.36	10	10.94	1	1.09

TABLE III.—D.

Table for converting yards into metres.

1 yard = 0.91443654 metre.

[9.9611536.]

Yards.	Metres.	Yards.	Metres.	Yards.	Metres.	Yards.	Metres.	Yards.	Metres.
100000	91443.65								
90000	82299.29	9000	8229.93	900	822.99	90	82.30	9	8.23
80000	73154.92	8000	7315.49	800	731.55	80	73.16	8	7.32
70000	64010.56	7000	6401.06	700	640.11	70	64.01	7	6.40
60000	54866.19	6000	5486.62	600	548.66	60	54.87	6	5.49
50000	45721.83	5000	4572.18	500	457.22	50	45.72	5	4.57
40000	36577.46	4000	3657.75	400	365.78	40	36.58	4	3.66
30000	27433.10	3000	2743.31	300	274.33	30	27.43	3	2.74
20000	18288.73	2000	1828.87	200	182.89	20	18.29	2	1.83
10000	9144.37	1000	914.44	100	91.44	10	9.14	1	0.91

TABLE III.—E.

Table for converting yards into miles.

1 yard = 0.000568182 mile.

[6. 7544873.]

Yards.	Miles.	Yards.	Miles.	Yards.	Miles.	Yards.	Miles.
100000	56. 818						
90000	51. 136	9000	5. 114	900	0. 511	90	0. 051
80000	45. 455	8000	4. 545	800	. 455	80	. 045
70000	39. 773	7000	3. 977	700	. 398	70	. 040
60000	34. 091	6000	3. 409	600	. 341	60	. 034
50000	28. 409	5000	2. 841	500	. 284	50	. 028
40000	22. 727	4000	2. 273	400	. 227	40	. 023
30000	17. 045	3000	1. 705	300	. 170	30	. 017
20000	11. 364	2000	1. 136	200	. 114	20	. 011
10000	5. 682	1000	0. 568	100	. 057	10	. 006

TABLE IV.

Length of a degree of the meridian, in nautical and statute miles, for each fifth degree of latitude between 20° and 50°.

1° of latitude.	In latitude.	1° of latitude.
Nautical miles.	°	*Statute miles.*
59. 669	20	68. 779
59. 706	25	68. 822
59. 749	30	68. 871
59. 796	35	68. 925
59. 847	40	68. 984
59. 899	45	69. 044
59. 951	50	69. 104

TABLE V.

Length of a degree of longitude, for each degree of latitude from 19° to 54°, expressed in nautical and statute miles.

1° of the equator = 60 nautical miles = 69.160 statute miles = 111, 306. 6 metres.

1° of longitude.		In latitude.		1° of longitude.	
Statute miles.	Nautical miles.	°	°	Nautical miles.	Statute miles.
65. 415	56. 751	19	37	47. 976	55. 300
65. 015	56. 404	20	38	47. 341	54. 568
64. 594	56. 039	21	39	46. 690	53. 819
64. 154	55. 657	22	40	46. 026	53. 053
63. 695	55. 259	23	41	45. 348	52. 271
63. 216	54. 843	24	42	44. 656	51. 473
62. 718	54. 411	25	43	43. 949	50. 659
62. 200	53. 962	26	44	43. 230	49. 830
61. 664	53. 497	27	45	42. 498	48. 986
61. 109	53. 016	28	46	41. 752	48. 126
60. 536	52. 518	29	47	40. 993	47. 251
59. 944	52. 005	30	48	40. 222	46. 362
59. 334	51. 476	31	49	39. 439	45. 460
58. 706	50. 931	32	50	38. 643	44. 542
58. 060	50. 370	33	51	37. 835	43. 612
57. 396	49. 794	34	52	37. 016	42. 668
56. 715	49. 203	35	53	36. 186	41. 710
56. 016	48. 597	36	54	35. 344	40. 740

TABLE VI.

Radii and co-ordinates for the polyconic development of a sphere, the radius of the sphere being assumed = 1.

Latitude.	x.	y.	Length of 10° of parallel.	Radius of parallel.
°				
0	3.142	0.000	0.1745	Inf.
10	2.942	0.823	0.1719	5.671
20	2.416	1.439	0.1640	2.747
30	1.732	1.732	0.1512	1.732
40	1.074	1.709	0.1337	1.192
50	0.563	1.461	0.1122	0.839
60	0.236	1.104	0.0873	0.577
70	0.069	0.721	0.0597	0.364
80	0.008	0.352	0.0303	0.176
85	0.001	0.175	0.0152	0.087
90	0.000	0.000	0.0000	0.000

APPENDIX No. 59.

Communication from Assistant Charles A. Schott, of the Computing Division, Coast Survey Office, on the determination of the probable error of an observation from the differences of the observations from their arithmetical mean.

WASHINGTON, *November* 26, 1856.

DEAR SIR: The practical value of the following article, taken from No. 1,034 of the Astronomische Nachrichten, has induced me to translate it, and to add an example.

"The determination of the probable error of observation by means of the sum of the differences, these being considered as essentially positive from their arithmetical mean, deserves attention on account of its simplicity. It has, therefore, been thought proper to develop the formulæ referring to this case.

Let p be the true value of a quantity repeatedly observed.

$a\ a'\ a''\ a''' \ldots$ the individual values and obtained under like circumstances

$\varepsilon\ \varepsilon'\ \varepsilon''\ \varepsilon''' \ldots$ the true errors of observation, and n the number of observations.

We then have

$$\begin{aligned} a &= p - \varepsilon \\ a' &= p - \varepsilon' \\ a'' &= p - \varepsilon'' \\ &\vdots \\ a^{(n-1)} &= p - \varepsilon^{(n-1)} \end{aligned}$$

The arithmetical mean of the observed values is

$$\frac{a + a' + a'' + \ldots + a^{(n-1)}}{n} = p - \frac{\varepsilon + \varepsilon' + \varepsilon'' + \ldots + \varepsilon^{(n-1)}}{n}$$

and their deviations from this mean are respectively

$$\frac{(n-1)\,\varepsilon - \varepsilon' - \varepsilon'' - \ldots}{n}$$

$$\frac{-\varepsilon + (n-1)\,\varepsilon' - \varepsilon'' - \ldots}{n}$$

$$\frac{-\varepsilon - \varepsilon' + (n-1)\,\varepsilon'' - \ldots}{n}$$

$$\vdots$$

We designate these quantities by $f\,f'\,f''$ . . . and their sum, considering them as positive, by Σf. If, as is here supposed, the observations are of the same weight, the same probable error ρ corresponds to each of the true errors $\varepsilon\,\varepsilon'\,\varepsilon''$ . . . . ; also, the probable error ρ' refers to the differences $f\,f'\,f''$ . . . . and is equal to

$$\rho\sqrt{\frac{(n-1)^2}{n^2}+(n-1)\frac{1}{n^2}}=\rho\sqrt{\frac{n-1}{n}}$$

The quantities $f\,f'\,f''$ . . . . are only subject to the condition, that their sum $= o$, hence the sum of the positive must equal the sum of the negative deviations. According to Gauss, the average value of a number of such differences, having the probable error ρ', equals

$$\frac{\rho'}{0.476936\ \sqrt{\pi}}=\frac{\Sigma f}{n}\ \text{hence}$$

$$\rho'=\frac{0.476936\ \sqrt{\pi}\ \Sigma f}{n}\ \text{but}\ \rho'=\rho\sqrt{\frac{n-1}{n}}$$

$$\text{hence}\ \rho=\frac{0.476936\ \sqrt{\pi}\ \Sigma f}{\sqrt{n\,(n-1)}}=0.845347\ \frac{\Sigma f}{\sqrt{n\,(n-1)}}$$

We meet generally with the formula $0.845347\ \frac{\Sigma f}{n-1}$ which give the value of ρ *a* little too large.''

Example.—The azimuth results at Webb station have been selected on account of the occurrence of one predominent value (thrown out by the criterion) and their small number, both circumstances tending to bring the formula to a severer test. We have

Mark E. of N.	Diff.	
° ′ ″		
6 07 44.88	− 0.76	
45.65	+ 0.01	lg. 0.845347 = 9.92704
45.89	+ 0.25	lg. 8.20 0.91381
44.80	− 0.84	c. lg. $\sqrt{90}$ 9.02288
46.55	+ 0.91	
44.78	− 0.86	$\rho = \pm$ 0″.73. 9.86373
*47.97	+ 2.33	and prob. error of mean $= \pm$ 0″.23.
44.03	− 1.61	by means of squaring we obtain for the same $\pm$ 0″.76 and $\pm$ 0″.24 respectively.
45.62	− 0.02	
46.25	+ 0.61	
Mean 6 07 45.64	+ 4.11	
	− 4.09	
	8.20	

I remain, sir, yours, very respectfully,

CHAS. A. SCHOTT.

Professor A. D. Bache.
Superintendent U. S. Coast Survey.

APPENDIX No. 60.

Description of an apparatus for measuring subsidiary base-lines.

Any apparatus for the measurement of base-lines, which does not, in a great degree, combine the principles and details of the principal base apparatus of the Coast Survey, must necessarily fall far short of it, not only in accuracy, but also in facility of use and despatch.

* Thrown out by the criterion, but here retained.

The compensation of the effects of temperature, with all the means for securing uniformity of action, the delicacy of the level of contact, the facility of adjustment in line and elevation afforded by the elaborate construction of the trestles, cannot be approached by appliances much short of that apparatus itself, and to it we must always look for the accurate ascertainment of distances.

There are many cases, however, of local surveys in advance of the primary triangulation, and of check measurements desired in extensive secondary series, in which an accuracy of lineal measurement less than that attainable with the compensating base apparatus is sufficient, and where the greater length of time required in using an inferior apparatus is compensated by the fact that it requires but little more than the usual force of a triangulation party to operate with it.

For the purposes indicated, different means have, at various times, been devised and used by the Assistants having charge of such work, and an apparatus designed by Assistant Boutelle is described in Appendix No. 41, Coast Survey Report for 1855.

The form of construction now presented is the result of a careful study of the subject by Assistant J. E. Hilgard and Mr. Joseph Saxton, in consultation with the Superintendent, with special reference to the experience with other apparatus. It has been used in the measurement of three lines during the past two years by different persons, and has given great satisfaction to the operators.

The principal points arrived at were the following:

1. To protect the iron rod from rapid changes of temperature, and to have a thermometer so placed that its indications will correspond to the temperature of the rod.

2. To effect the contact of the rods, or coincidence of lines by a continuous screw-motion.

3. In the construction of the supports, to combine a large range in elevation with the means of making a nice final adjustment.

The manner in which these ends have been attained may be seen on Sketch No. 64, where the apparatus is figured. A round iron rod, of one quarter inch diameter, and four metres long, is encased in a solid wooden bar, three inches wide and six inches deep, composed of two pieces firmly screwed together, as seen in figures 1 and 2. Figure 3 shows the manner in which the thermometer is inlaid in the middle of the bar, so as to bring the bulb near the iron rod, the top of its case closely filling up the aperture. In practice, the thermometer is withdrawn and read every twenty minutes or half hour. The temperature of the rod changes slowly; and, while it never differs greatly from that of the air, it is unaffected by alternations of sunshine and clouds, which greatly affect the indications of an exposed thermometer.

In figure 1, the upper part of the wooden bar is taken off in order to show the details of the arrangement for making the contact; *a* is the forward end of a rod already in position, armed at the end with a plane of hardened steel; *a'* is a portion of the forward bar about to be brought into position, in contact with *a*. Each rod is movable lengthwise in its groove by the action of a screw *d*, counteracted by the spring *e*; *f* is a short tube armed with a steel knife-edge which slides over the end of the rod, and is pushed outward by a spiral spring rather more than sufficient to overcome its friction, (see figure 7,) and has a delicate line drawn on it, the coincidence of which with a similar line on the index plate *i* fastened to the rod, determines that position of the slide in which the knife-edge is at the known distance from the plane at the other end of the rod. The silver index-plate *i* is visible through a slot in the sliding piece, called the abutting slide. The plate *j* passes through a notch in the collar *k*, and prevents the rod from twisting by the action of the screw.

When the whole bar is nicely adjusted on the trestles or stands in elevation and alignment, and within one-eighth of an inch in distance either way, the exact adjustment is effected by sliding the rod within the bar by means of the screw *d* and spring *e* until the lines on the index-plate and abutting-slide coincide, the knife-edge on the latter abutting meanwhile against the steel plane of the preceding bar, which suffers no pressure except that due to the small spiral spring within the abutting slide. In judging of the coincidence of lines, a magnifyer is made use of, which can be conveniently attached to the bar, or carried by the operator.

Figures 4, 5, and 6 show the improved stand.

On a tripod stand, with double legs of the usual construction, is screwed a cross-piece l, carrying the upright guides m, m, to which can be clamped at any elevation the cross-piece n, which has a small spirit-level attached, to indicate its horizontal position. A similar cross-piece o, can be moved parallel to n, up or down, half an inch from its average position by means of the wedge p, as the drawing shows abundantly.

The bars being four metres in length, the stands are set up at distances of two metres, each bar being supported at one-fourth its length from the ends. The height of the stands is approximately adjusted by the spreading of the legs, and the cross-pieces n are clamped at a suitable height, which is ascertained by sighting across the top of the pieces o to a bar already in position, the wedges p being placed in their average position. The bar is next placed on the stands in approximate alignment, for which the space between the uprights makes ample allowance, if the stands are set with moderate care; it is then adjusted in elevation by means of the wedges, and either placed level or at any required inclination. The alignment is now perfected, for which purpose a slight piece of brass wire q, is inserted near each end on top of the bar, which is merely shifted by hand, and not in any way clamped to the stands, as its weight is quite sufficient to insure stability; at the same time the position in distance is approximately so adjusted as to bring the perfecting of it within reach of the screw motion.

A couple of small spirit-levels attached to each bar, one near each end, where it is conveniently seen by the persons operating the wedges, expedite greatly the work of adjusting the bars to a level, which is, on the whole, the best mode of using the apparatus, considerable changes of level in the ground being overcome by making a vertical offset with a theodolite. A sector with spirit-level, placed on top of each bar near the middle of its length, may be used for measuring inclinations, if desired, and accompanies the apparatus.

Considerable irregularity of ground can be overcome by means of the stands described, as they afford a vertical range of about two feet.

The apparatus is provided with three pairs of stands, and six persons operate it with facility. Three persons to carry forward the stands, set them, and approximately adjust the cross-pieces; two to carry forward the bars, and, stationed at the stands, manipulate for its nice adjustment under the direction of the operator between the bars, who makes the contact. An additional hand is required to transport tools, theodolite, water, &c.

The apparatus was first used in May, 1855, in remeasuring a portion of Dauphine Island Base, between marks that had been left in the original measurement with the compensating base apparatus. One hundred and eighty-nine bars, or nearly half a mile, were measured at the rate of a little over three minutes to the bar, and the distance agreed with that previously measured, within two-tenths of an inch.

In the same year, a line of 717 bars, or one and three-quarters of a mile, was measured on Chandeleur Island, at the rate of two and one-fifth minutes to the bar; and, subsequently, a line of over one mile was measured, near Pensacola, at precisely the same rate of speed.

APPENDIX No. 61.

Method of testing a repeating Theodolite, illustrated by Assistant J. E. Hilgard.

A new ten-inch repeating theodolite, C. S. No. 79, having been constructed by Mr. Wm. Würdemann, and graduated with great care on the Coast Survey dividing-engine, it was thought desirable thoroughly to test its qualities before taking it to the field, and to compare it, at the same time, with two similar instruments, by Gambey, just received. The same process, which will be fully described, was applied to the three instruments, and of the comparisons it is only necessary to say here, that in all points of construction, parellelism of axes, power of telescopes, levels and clamps, the preference was given to the instrument by Mr. Würdemann, except in the matter of graduation, in which the Gambey theodolites are, at least, fully equal.

A brief notice of the principal points in the construction of the instrument will suffice here, the main purpose of this article being to give an example of the mode of examining such an instrument.

Theodolite No. 79 was designed not only for the measurement of horizontal angles between objects nearly in the plane of the horizon, but also for the determination of azimuth by observations of circumpolar stars; hence the transit axis of the telescope has been made longer than would be requisite for the former purpose merely; the form of its pivots has received particular attention, and the axis is perforated and provided with a mirror for illuminating the field of view. A counterpoise to the lamp is provided, to be attached to the opposite pillar whenever the lamp is used. The pillars are of sufficient height to admit of revolving the telescope about its axis. The focal length of the telescope is 18 inches, aperture of object glass $2\frac{1}{4}$ inches, and the magnifying power generally used is 36. The length of the transit axis is 10 inches, and the value of one division of the striding level is $1''.56$, the length of a division being equal to one millimetre, or one twenty-fifth part of an inch.

One of the principal novelties in the construction is the form of the lower clamp, which holds the circle to its base, it being a circular clamp, similar to that which is usually employed to clamp a telescope in altitude.

The alhidade carries two "flush" verniers, very little depressed below the plane of the graduated circle. On the Gambey circle this depression is considerable, and while it gives rise to parallax affecting the reading, which is hardly entirely remedied by the long sight-tube in which the magnifying lens is mounted, it does away with the appearance of a dividing line between the vernier and circle, which somewhat impedes our judgment of the coincidence. Observers will probably differ in their preference for one of these forms over the other, as they may be individually more affected by the parallax or the dividing line.

The verniers in No. 79 are disposed at an angle of 45° with the direction of the telescope, and can be read without danger of touching with the hand, either the latter, while remaining pointed, or the pillars supporting it. They are carried by a thin, slightly conical plate, without perforations, which removes all danger from flexure of the radii or spokes more generally employed.

The alhidade is also provided with two small levels, at right angles to each other, of sufficient delicacy to be used in levelling the instrument for the ordinary measurement of angles.

For the purpose of examining the graduation and determining the eccentricity of the alhidade, readings of the two verniers were made at each 10° of the graduation, vernier A being set each time to the precise reading; the circle was brought round 180° for the purpose of reading B under the same illumination, and, after setting the verniers forward 10°, the circle was moved back through that angle, so that the person reading did not change his position.

The readings, so taken, are recorded below, in Table I, where they are arranged in two sets, those readings differing 180° being placed on the same line.

TABLE I.

Readings of every ten degrees on the circle, and determination of angular distance of verniers.

I.			II.			B—A.			Δ	Δ²
A.		B.	A.		B.	I.	II.	Mean.		
° ′	″	″	° ′	″	″	″	″	″	″	
0 00	00	10	180 00	00	55	+ 10	— 5	+ 2.5	— 1.0	1.00
10 00	00	10	190 00	00	00	+ 10	0	+ 5.0	+ 1.5	2.25
20 00	00	05	200 00	00	00	+ 5	0	+ 2.5	— 1.0	1.00
30 00	00	05	210 00	00	00	+ 5	0	+ 2.5	+ 1.0	1.00
40 00	00	05	220 00	00	05	+ 5	+ 5	+ 5.0	+ 1.5	2.25
50 00	00	05	230 00	00	05	+ 5	+ 5	+ 5.0	+ 1.5	2.25
60 00	00	05	240 00	00	05	+ 5	+ 5	+ 5.0	+ 1.5	2.25
70 00	00	05	250 00	00	05	+ 5	+ 5	+ 5.0	+ 1.5	2.25
80 00	00	05	260 00	00	05	+ 5	+ 5	+ 5.0	+ 1.5	2.25
90 00	00	05	270 00	00	00	+ 5	0	+ 2.5	— 1.0	1.00
100 00	00	05	280 00	00	00	+ 5	0	+ 2.5	— 1.0	1.00
110 00	00	05	290 00	00	00	+ 5	0	+ 2.5	— 1.0	1.00
120 00	00	05	300 00	00	00	+ 5	0	+ 2.5	— 1.0	1.00
130 00	00	05	310 00	00	00	+ 5	0	+ 2.5	— 1.0	1.00
140 00	00	00	320 00	00	05	0	+ 5	+ 2.5	— 1.0	1.00
150 00	00	00	330 00	00	10	0	+ 10	+ 5.0	+ 1.5	2.25
160 00	00	55	340 00	00	10	— 5	+ 10	+ 2.5	— 1.0	1.00
170 00	00	55	350 00	00	10	— 5	+ 10	+ 2.5	— 1.0	1.00
Angular distance of verniers = 180° + 3.″5								18)62.5 + 3.″5		17)26.75 $m^2 = 1.57$ $m = 1.''25$

The differences of the readings of verniers A and B may be due, *first*, to their constant angular distance being slightly more or less than 180°, which we will designate by $180 + \lambda$; *secondly*, to eccentricity of the alhidade, or the centre of its axis not coinciding precisely with the centre of the graduated circle; *thirdly*, to errors of graduation on the circle; and, *fourthly*, to the accidental errors of reading. If we designate by μ the effect of eccentricity on the difference of the verniers, we have, for any position of the verniers, $B - A = 180° + \lambda + \mu$; and, for a position differing 180° from the former, $B - A = 180° + \lambda - \mu$. Thus, if we take the mean of the differences B — A for readings differing 180°, as placed in juxtaposition in the table, this mean will express the angular distance of the verniers cleared of the effect of eccentricity, but each value affected by errors of graduation and reading. The column *Mean*, under B — A, gives these values, the mean of which is + 3″.5, showing that the zero on vernier B is distant from that on vernier A by 180° 00′ 03″.5.

The differences Δ of the several values from this mean are due to errors of graduation and reading; if we ascribe to the indication of one vernier the mean error m, arising from both sources, each of the differences B—A is affected by the mean error $m\sqrt{2}$, and the mean of two such differences is again affected by the mean error $m = \sqrt{\frac{\Sigma \Delta^2}{n-1}} = 1''.25$.

Acccording to this table, the errors of graduation appear exceedingly small; indeed, since the uncertainty of reading is included in the value of m, and since that cannot be estimated at less than half the closest indications of the verniers, or 2″.5, m is obviously too small, which must be ascribed to a compensation of errors peculiar to this method of treatment. In the sequel, a larger and more probable value is found for the same uncertainty, from the same readings that form the basis of the above discussion.

In order to determine next the eccentricity of the instrument, we subtract from the differences

B—A in table I the constant difference $+ 3''.5$ of the verniers. The residuals will be composed of the effect of eccentricity and accidental errors of graduation and reading, and are given in table II under the head $\mu + m$. If we now designate by ε the angular value of the eccentricity, or the distance of the centre of graduation from that of motion, expressed in seconds of arc for the radius of the graduated circle, and by ρ that reading on the limb which would be designated by a line passing from the centre of graduation through that of motion to the limb, then $(r-\rho)$ is the angle which the verniers make for any reading r, with the line of eccentricity, and $2\,\varepsilon \sin (r-\rho) = \mu$ will be the effect of eccentricity in the differences of the vernier-readings. Moreover, for any reading r' differing 180° from r, the effect of eccentricity will be the same in amount as for r, but with opposite sign, or $\mu' = -2\,\varepsilon \sin (r-\rho)$. In table II, therefore, the values in columns I and II should be respectively equal, with opposite signs, if they were not affected by the accidental errors m. The next column gives $\sigma =$ half the difference of the preceding values, which correspond to $\mu = 2\,\varepsilon \sin (r-\rho)$, affected in a less degree by the accidental errors of reading and graduation.

In order to derive the values of ε and ρ from those of σ in the table, we observe that they correspond respectively to the following equations:

$$\text{For } 0°,\ \sigma_1 = 2\varepsilon \sin (\ 0° - \rho) = 2\,\varepsilon\,(\sin\ 0° \cos \rho - \cos\ 0° \sin \rho).$$
$$\text{For } 10°,\ \sigma_2 = 2\varepsilon \sin (\ 10° - \rho) = 2\,\varepsilon\,(\sin\ 10° \cos \rho - \cos\ 10° \sin \rho).$$
$$\text{For } 120°,\ \sigma_3 = 2\varepsilon \sin (120° - \rho) = 2\,\varepsilon\,(\sin 120° \cos \rho - \cos 120° \sin \rho).$$

&c., &c., &c.

Of which equations we have 18, or half the number n of readings made.

Resolving these equations, by the method of least squares, with reference to $2\,\varepsilon \cos \rho$, and $2\,\varepsilon \sin \rho$, we find

$$2\,\varepsilon \cos \rho = \tfrac{2}{n}\,(\sigma_1 \sin 0° + \sigma_2 \sin 10° + \ldots + \sigma_{18} \sin 170°).$$
$$2\,\varepsilon \sin \rho = \tfrac{2}{n}\,(\sigma_1 \cos 0° + \sigma_2 \cos 10° + \ldots + \sigma_{18} \cos 170°).$$

the first of which expressions is the mean of the products of the several values of σ into the sines of the corresponding angles on the limb, and the second the mean of the products of the same values into the cosines.

Table II gives these sines, cosines, and products, and the sums of the latter. In dividing $2\,\varepsilon \sin \rho$ by $2\,\varepsilon \cos \rho$, the factor $\frac{2}{n}$ disappears, and we have

$$\tan \rho = \frac{\Sigma\,(\sigma \cos r)}{\Sigma\,(\sigma \sin r)} = \frac{+\,33.4}{+\ \ 6.5} = \tan 79°, \text{ and } \rho = 79°.$$

For ε we have, further, $2\,\varepsilon \sin 79° = \dfrac{33.4}{18}$, and $\varepsilon = 1''.9$.

TABLE II.

Determination of Eccentricity.

r.	$\mu+m$ I.	$\mu+m$ II.	$\frac{\text{I—II}}{2}=\sigma$	Sin. r.	Cos. r.	σ Sin. r.	σ Cos. r.
°	″	″	″			″	″
0	+ 6.5	— 8.5	+ 7.5	0.00	1.00	0.0	+ 7.5
10	+ 6.5	— 3.5	+ 5.0	.17	.98	+ 0.9	+ 4.9
20	+ 1.5	— 3.5	+ 2.5	.34	.94	+ 0.9	+ 2.3
30	+ 1.5	— 3.5	+ 2.5	.50	.87	+ 1.2	+ 2.2
40	+ 1.5	+ 1.5	0.0	.64	.76	0.0	0.0
50	+ 1.5	+ 1.5	0.0	.76	.64	0.0	0.0
60	+ 1.5	+ 1.5	0.0	.87	.50	0.0	0.0
70	+ 1.5	+ 1.5	0.0	.94	.34	0.0	0.0
80	+ 1.5	+ 1.5	0.0	.98	.17	0.0	0.0
90	+ 1.5	— 3.5	+ 2.5	1.00	.00	+ 2.5	0.0
100	+ 1.5	— 3.5	+ 2.5	.98	— .17	+ 2.5	— 0.4
110	+ 1.5	— 3.5	+ 2.5	.94	— .34	+ 2.3	— 0.8
120	+ 1.5	— 3.5	+ 2.5	.87	— .50	+ 2.2	— 1.2
130	+ 1.5	— 3.5	+ 2.5	.76	— .64	+ 1.9	— 1.6
140	— 3.5	+ 1.5	— 2.5	.64	— .76	— 1.6	+ 1.9
150	— 3.5	+ 6.5	— 5.0	.50	— .87	— 2.5	+ 4.3
160	— 8.5	+ 6.5	— 7.5	.34	— .94	— 2.5	+ 7.0
170	— 8.5	+ 6.5	— 7.5	.17	— .98	— 1.3	+ 7.3
						+14.4	+ 37.4
						— 7.9	— 4.0
						+ 6.5	+ 33.4

To determine the residual errors of graduation and reading, we form Table III by computing $\mu = 2\varepsilon \sin r$ for each reading, and subtracting these values of μ from those of $\mu + m$ in Table II, bearing in mind that μ has the same value for $180° + r$ as for r, with reversed sign. We thus obtain the values of m, which are compounded of two errors of graduation and reading combined, being the difference of readings of verniers A and B, cleared of λ and μ.

TABLE III.

Residual errors of graduation and readings.

r.	Sin. r.	2ε Sin. r.	r.	m.	r.	m.
°		″	°	″	°	″
0	.982	+ 3.7	0	+ 2.8	180	— 4.8
10	.934	+ 3.5	10	+ 3.0	190	0.0
20	.857	+ 3.3	20	— 1.8	200	— 0.2
30	.755	+ 2.9	30	— 1.4	210	— 0.6
40	.629	+ 2.4	40	— 0.9	220	+ 3.9
50	.485	+ 1.8	50	— 0.3	230	+ 3.3
60	.326	+ 1.2	60	+ 0.3	240	+ 2.7
70	.156	+ 0.6	70	+ 0.9	250	+ 2.1
80	.017	— 0.1	80	+ 1.6	260	+ 1.4
90	.191	— 0.7	90	+ 2.2	270	— 4.2
100	.358	— 1.4	100	+ 2.9	280	— 4.9
110	.515	— 2.0	110	+ 3.5	290	— 5.5
120	.656	— 2.5	120	+ 4.0	300	— 6.0
130	.777	3.0	130	+ 4.5	310	— 6.5
140	.875	— 3.3	140	— 0.2	320	— 1.8
150	.946	— 3.6	150	+ 0.1	330	+ 2.9
160	.988	— 3.8	160	— 4.7	340	+ 2.7
170	.999	— 3.8	170	— 4.7	350	+ 2.7

The sum of the squares of the thirty-six residuals m is 370, hence the mean uncertainty of one is $\sqrt{\frac{370}{35}} = \pm 3''.2$, which, divided by the square root of two, gives $\pm 2''.3$ as the mean uncertainty of the indication of one vernier, as depending on accidental errors of reading and graduation.

The same uncertainty is to be ascribed to an angle resulting from the subtraction of the mean of two vernier-readings from another mean; and, when such an angle is the sum of six repetitions, the uncertainty from those sources to be ascribed to the single angle is one-sixth of $\pm 2''.3$ or $\pm 0''.4$.

We have thus ascertained that the angular distance of the verniers is 180° 00′ 03″.5, that the eccentricity of the centre of motion is 1″.9 in the direction from the centre of graduation to the reading of 79° on the limb, and that the mean uncertainty of the indication of one vernier is $\pm 2''.3$.

Parallelism of vertical axis.—It is a point of great importance in a repeating circle that the axis of the alhidade should be, as nearly as possible, parallel to that of the circle, since, unless such is the case, the instrument will be changing its plane during the repetition of angles, and the effect of this is very sensible in observations of azimuth. An obvious mode of testing this point is by levelling the instrument by reversals on one axis, and then examining whether the indications of the level will remain uniform while it is revolved about the other axis. But a simpler mode is the following: after levelling the instrument as nearly as may be, revolve the circle about the alhidade, the latter being held in its position by the hand, and watch the indications of the striding level, which will not change if the two axes are parallel. The following experiment was made in this manner with the instrument in question:

Circle reads	0° ;	level reads	E. 42.2,	W. 52.0
"	90°	"	41.8,	52.7
"	180°	"	43.1,	51.3
"	270°	"	42.2,	52.2
"	360°	"	42.3,	52.1

The greatest difference of indication in opposite directions is between the readings 0° and 180°, and amounts in the mean of both readings to 0.8 divisions, which is equal to about one second of arc; a degree of accuracy seldom attained.

Figure of pivots.—The cylindrical form and equality of pivots of the telescope is ascertained by means of the striding level.

The telescope can be turned into all positions in which it is actually used, while surmounted by the level, the varying indications of which, while the telescope is gently and slowly revolved through such arcs as the position of the level will admit of, will show how far the figure of the pivots deviates from being perfectly circular. A number of experiments showed that their form was perfect within half a second of arc.

The effect of any inequality in the diameters of the two pivots is compensated by the reversal of the instrument, which is necessary in all classes of observations; but, as a point of workmanship, this should also be examined into.

The instrument being firmly mounted and levelled, the striding level is placed on the pivots and read in direct and reversed positions; the telescope is next lifted out of its bearings and reversed so as to interchange pivots and bearings; the level being again read in both positions, the difference in the indications is caused by twice the difference in the diameters of the pivots.

This proceeding is too simple to require illustration by an example; in the case before us, the average inequality was found to be 1″.2, by which the pivot at the illuminated end of the axis is smaller than the other one, amounting in linear measure to one seventeen-thousandth part of an inch. Investigations like the foregoing will greatly tend to increase our confidence in an instrument, or, if there are material defects, will point out their nature. The actual performance, however, of a theodolite in the measurement of angles, must always be the ultimate test of its qualities. The comparison of the means of repeated measurements of an angle between two well defined objects, in different positions of the circle, and of the results of repetitions of the same angle, will always constitute the best criterion of its merits.

APPENDIX No. 62.

Report of Assistant George Mathiot, on the results of an experiment made in printing maps from their electrotyped plates.

COAST SURVEY OFFICE, ELECTROTYPE DIVISION,
December 1, 1856.

DEAR SIR: A short time before your return to the charge of the office, I commenced, by direction of Professor Bache, a set of experiments on the use of thin electrotypes of engraved plates for printing, instead of the castings equal in thickness to the original engraved plates heretofore used.

The plate of "Horn Island Pass" was selected for the trial. The alto was prepared and placed in the vertical vat on one afternoon, and removed on the second morning following, in which time it received a thickness of about that of our map paper, which was more than I desired to have, for I am satisfied that even the half of that thickness may be used. The elevations of the work on the back of the plate were rubbed down by Mr. Patterson with a piece of pumice-stone, and the edges of the thin plate were folded under the edges of an old alto, from which the elevations were erased, and the plate placed in the hands of Mr. J. Rutherdale to print under my direction. I instructed him to note any changes he might observe in regard to the plate while under pressure. The printing has been several times suspended to give place for more urgent work; but over three hundred copies are now off, and Mr. Rutherdale reports that he observes nothing more in printing from this plate than from the usual thick electrotypes, and should have known no difference but for my intimation in reference to its peculiarities.

This plate cannot, however, be tested as to its capabilities for printing, as it would furnish several thousand impressions, and that number is not wanted.

The time actually consumed in the production of the plate was not over half a day; this included the battery-work, the rubbing down the back, the cutting and smoothing the alto used for the support-plate, and the whole was in the hands of the printer in less than forty-eight hours from the time it was commenced.

I hardly think anything remains to prove that the basso plates may be used to great advantage, that the process described will facilitate the production of the charts of the survey, and greatly economize the time and labor of the electrotype division.

I have the alto of "Nantucket Shoals" in course of making, and, when finished, I propose (with your approbation) to make a thin basso of it for printing the edition now wanted.

After the preliminary experiments had shown that thin plates might be used to print from, I applied it to a number of chart plates for testing its value and discovering any peculiarities which might be required in the use and manufacture of these plates. The plates in the following list were thus produced and used for printing:

Horn Island Pass printed 250 charts, is still good.
Portland harbor printed 250 charts, is still good.
Nantucket shoals printed 280 charts, is still good.
Port Townshend printed 250 charts, is still good.
Cedar keys printed 430 charts, split in the border.
Minot's ledge printed 250 charts, split on the edge.
Boston harbor printed 450 charts, split on the edge.

These plates printed precisely as the ordinary plates, in regard to facility of handling and the number of copies they could furnish. The splitting, I supposed, was owing to the peculiar quality of the metal, which was brittle in all those which split. Of course this was at my command, as I can make the metal malleable or brittle; but I discovered that, as I had necessarily to use the vertical vat to make them, the slow diffusion of the newly formed salt at the constantly decreasing temperatures then prevailing would not allow me to work at the rate required for the most plastic metal, and at the same time keep the backs of the plates smooth.

When I began making the thin plates the temperature was 90 in the solutions, and then I found it very easy to make good plates which would not split; but as the temperature fell to 60 I found it entirely impracticable.

The thin plates weigh from a sixth to a fourth of the thick ones, and, of course, they require only a proportionate amount of copper, zinc, acid, &c., and time for their production. I stretched them on plates of zinc, one-tenth of an inch in thickness; but iron would be better, if we could procure a suitable article. This makes the whole expense probably one-fourth or one-third of the thick ones; but one stretch plate will always answer for the thin plates of the same chart.

Very truly, yours, &c.,

GEORGE MATHIOT.

Lieut. A. P. Hill, U. S. A.,
Acting Assistant in charge of Coast Survey Office.

APPENDIX No. 63.

Letter to the Superintendent, communicating results of analysis made of specimens of the water of New York harbor, by Professor Wolcott Gibbs.

New York, *April* 27, 1856.

Dear Sir: Agreeably to your request, I have determined the specific gravities and the quantities of saline matter in eleven samples of water taken from different parts of New York harbor. The samples were delivered to me in corked wine bottles, carefully labelled, the date, the place from which the water was taken, the depth beneath the surface, and in some cases the temperature and time of collecting (hour of the day) being given. The state of the tide was also noted. The results of my examination are as follows:

Sample 1. Off Vanderbilt's landing, Staten Island, March 8, 1856, 1 foot below the surface, temperature 33° Fahrenheit: spec. grav. 1.0205, at 15° 5c., saline matter 2.706 per cent.

Sample 2. Station No. 4, off the foot of 17th street, East river, March 5, 2 p. m., 1 foot below the surface: spec. grav. 1.0178, at 14°c., saline matter 2.463 per cent.

Sample 3. Station No. 7, mouth of Navesink river, N. J., March 19, temperature 33° Fahr., 5 feet below the surface: spec. grav. 1.0177, at 15°c., saline matter 2.513 per cent.

Sample 4. Station No. 1, off Washington Heights, March 13, 5 feet below the surface: spec. grav. 1.0126 at 15° 25c., saline matter 1.702 per cent.

Sample 5. Station No. 3, off pier No. 1, North river, March 6, a. m., one foot below the surface: spec. grav. 1.0182 at 15° 2c., saline matter 2.348 per cent.

Sample 6. Off Vanderbilt's landing, Staten Island, March 8, 5 feet below the surface: spec. grav. 1.0188 at 10°c., saline matter 2.707 per cent.

Sample 7. Station No. 3, off pier No. 1, North river, March 6, 5 feet below the surface: spec. grav. 1.0192 at 18°c., saline matter 2.533 per cent.

Sample 8. Station No. 3, off pier No. 1, North river, March 6, 1 foot below the surface: spec. grav. 1.0183 at 15°c., saline matter 2.351 per cent.

Sample 9. Station No. 5, Buttermilk channel, March 6, 5 feet below the surface: spec. grav. 1.0155 at 16°c., saline matter 2.132 per cent.

Sample 10. Station No. 1, off Washington Heights, North river, March 13, 6 inches below the surface: spec. grav. 1.0111 at 15° 5c., saline matter 1.585 per cent.

Sample 11. Station No. 4, off foot of 17th street, East river, 5 feet below the surface, March 5, p. m.: spec. grav. 1.0185 at 16°c., saline matter, 2.461 per cent.

It is proper to remark that the specific gravities given above all refer to that of pure water at the temperature of 14°c.

Very respectfully, yours,

WOLCOTT GIBBS,

Professor of Chemistry and Physics in the Free Academy in New York.

A. D. Bache, LL. D.,

Superintendent Coast Survey.

Analysis of specimens of water from New York harbor and vicinity.

Date.	Time.	No. of station.	Distance below surface.	Specific gravity.	At temperature of—	Saline matter.	Temperature, Fahr. Water.	Temperature, Fahr. Air.	State of current.	State of tide.	General position in channel.
1856.	P. M.		*Feet.*		°	*Per cent.*	°	°			
Mar. 13	4.00–4.30	1	.5	1.0111	15.5 *c.*	1.585	30	31	Slack	$\frac{6}{10}$ ebb	Off Washington Heights, H. R.
		2									
	A. M.										
6	10.30–11.15	3	1.	1.0182	15.2 *c.*	2.348	34½	36½	Slack	$\frac{4}{10}$ ebb	Off pier No. 1, H. R.
			5.	1.0192	18. *c.*	2.533					
			1.	1.0183	15. *c.*	2.351					
	P. M.										
5	2–2.45	4	5.	1.0185	16. *c.*	2.461	31	31½	Slack	Slack	East river, off 17th street.
			1.	1.0178	14. *c.*	2.463	31	31½			
6	3½–4¼	5	5.	1.0155	16. *c.*	2.132	35	41½	Flood	¼ flood	Buttermilk channel.
	P. M.										
8	12*h.*–1*h.*	6	1.	1.0205	15.5 *c.*	2.706	33	39½	Ebb	$\frac{8}{10}$ ebb	Off Vanderbilt's landing, S. I.
	A. M.										
19	7¾	7	5.	1.0177	15. *c.*	2.513	33	33	Flood.	$\frac{1}{10}$ ebb	Mouth Navesink river, N. J.

Note.—The columns of "temperature, water and air," represent the state at time of obtaining the water.
The column "state of tide," shows proportion of total rise or fall at time of obtaining the water.
The specific gravities given above all refer to that of pure water at the temperature of 14° *c.*

APPENDIX No. 64.

Letter to the Superintendent from Professor Wolcott Gibbs, communicating results of examinations made of sands taken from the sites of Coast Survey bases at Key Biscayne (Cape Florida) and Cape Sable.

New York, *July* 21, 1855.

Dear Sir: I have taken the earliest opportunity of examining the Cape Sable sands, which you placed in my hands, and find them to consist essentially of mixtures of sand, organic matter, and carbonate of lime. All the specimens effervesced strongly with muriatic acid. A quantity of a very white sand remained undissolved, while much flocky organic matter was suspended in the solution, and could be separated by filtration. The filtrate was yellow, and contained much lime, a little magnesia, and peroxide of iron, and sometimes traces of alumina. The flocky-matter examined under the microscope showed abundance of organic forms. The specimens from Cape Sable base, end of the second mile, six inches below the surface, contained much very dark colored organic matter in addition to the ingredients mentioned above. The two specimens of coarse sand from Key Biscayne contained a large quantity of clear white sand, little organic matter, and perhaps twenty per cent. of carbonate of lime, &c., as above. I did not find phosphoric acid in any of the samples, even by testing with molybdate of ammonia; still there may be a trace. There was a remarkable similarity between the samples, so that the same description applies to all.

Very respectfully, and truly, yours,

WOLCOTT GIBBS.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 65.

Abstract of an historical memoir concerning the progress of exploration on the Atlantic coast of the United States, from its discovery to the present time.

[Prepared by Dr. J. G. KOHL, for the archives of the U. S. Coast Survey.]

WASHINGTON, D. C., *November* 1, 1856.

DEAR SIR: In compliance with your request to compose for the Coast Survey a work on the history of the eastern or Atlantic coasts of the United States, similar to the works on the Pacific and Mexican Gulf coasts, which I delivered to you at a former occasion, I have now the honor and pleasure of presenting to you the complete manuscript of the work desired.

I have arranged it according to the plan adopted for the other works, and it is therefore like those divided into three parts—a historical, a treatise properly termed hydrographic, and a bibliographical part.

THE FIRST OR HISTORICAL PART contains a history of the discovery and exploration of the coast from the time of the expeditions of the Northmen to the time of the final settlement of the coast, in ten chapters.

The first chapter contains a review of the time before Columbus, and a short sketch of the history of the Scandinavian expeditions towards the east coast in the tenth and eleventh centuries.

The second chapter relates in substance the result of the first English expedition to the coast under Sebastian Cabot, at the end of the fifteenth century, which in extent, fame, and importance stands quite alone, and was not soon followed by a similar enterprise.

The third chapter contains the history of the early Spanish, French, and English expeditions towards the eastern coast during the first quarter of the sixteenth century, and shows the relative merit of Ponce de Leon, Alaminos, Ayllon, Verrazano, Estevan Gomes, as compared with certain English navigators, in regard to the early exploration of the coast. All these expeditions followed each other at short intervals, and therefore form, as it were, one historical group.

In the fourth chapter I have reviewed the operations of Fernando de Soto and his naval captains Diego Maldonado and Gomez Arias, so far as they relate to the east coast, and have given an abridgement of the remarkable geographical description of the coast by Oviedo, which was written after the expeditions just named.

The fifth chapter contains the history of the French expeditions to the east coast soon after the middle of the sixteenth century, by Ribaut, Laudonnière, and Gourgue, and likewise of the

English and Spanish expeditions, commanded by Hawkins, Don Pedro Menendes de Avila, which were more or less connected with the former. Through this connection with the French expeditions a knowledge of the southern half of the east coast was more rapidly developed.

The sixth chapter contains the history of the first English expeditions to Virginia at the end of the sixteenth century, under the direction of Sir Walter Raleigh, and commanded severally by Amadas, Barlow, Greenville, Ralph Lane, John White, and others.

The seventh chapter relates the early French and English discoveries on the shores of New England at the beginning of the seventeenth century, and gives the history of the expeditions under Captains Gosnold, Gilbert, Pringe, De Monts, Champlain, Weymouth, &c.

The eighth chapter contains accounts of the early English voyages to Chesapeake bay, under Captains Newport and Smith, and shows how the regions round Chesapeake bay were explored during the first quarter of the seventeenth century.

The ninth chapter contains the history of a second series of more minute explorations of the coast of New England, under the direction of the Plymouth company, during the first quarter of the seventeenth century, by the English captains Topham, Gilbert, Argall, Smith, Dermer, Levett, and others.

The tenth chapter contains the history of the Dutch discoveries and of expeditions to the regions between Virginia and New England, executed likewise during the first quarter of the seventeenth century, by the navigators, Hudson, Block, Christiansen, Hendricksen, May, Vries, and others.

By these numerous expeditions of the French, English, Dutch, and other nations, during the first quarter of the seventeenth century, the hydrography of the eastern coast became known and settled in its principal features, in a remarkably short period; and the more minute work of exploration and survey of the details commenced here much earlier than on the coasts of the Mexican Gulf and the Pacific.

In a "*conclusion*" to the historical memoir, I have given reasons for preferring to give the history of the subsequent numerous small expeditions which explored all the different single points and localities, not in a chronological, but in a geographical order, and why they are treated under each particular name in the second part of the work. The historical memoir is illustrated by a historical map of the Eastern Coast, executed according to the principles of similar maps which accompany the works on the Mexican Gulf and Pacific Coasts. The tracks of the principal discoverers and explorers of the coast are given on it in different colors. Their names, the dates and the points of commencement and termination of the several expeditions are marked. To all the principal bays and harbors is appended a list of the names of their principal explorers.

THE SECOND PART OF THE WORK contains a review of the names of the principal points, capes, bays, ports, islands, &c., of the Atlantic Coast of the United States, from Passamaquoddy bay to Cape Florida. To every name is added a little essay or note, giving the origin and changes of the name and the history of the exploration of the indicated locality.

The names are put in geographical order, from the North to the South, and are divided into twenty chapters. As the primitive divisions of the Eastern Coast were neither so definitely marked, nor so generally known and admitted as those of the Mexican Gulf, I preferred to adopt the political sub-divisions into States. It is, however, difficult to cling to one principle of division exclusively, and therefore, as in the case of Long Island, I resorted to the natural division, and in some others to very important localities, assigning to the names of New York harbor, &c., special chapters. Most of the names occurring on the Eastern Coast are arranged under the following twenty heads or chapters:

1. Coast of Maine.—From Passamaquoddy bay to Portsmouth harbor.
2. Coast of New Hampshire.—From Portsmouth harbor to Hampton.
3. Coast of Massachusetts.—From Newburyport to Manomet Point.
4. Barnstable Peninsula.—From Barnstable harbor to Monomoy island.

5. The islands and bays south of Barnstable peninsula.—From Monomoy island to Elizabeth islands.
6. Coast of Rhode Island.—From Saughkonnet Point to Stonington Point.
7. Coast of Connecticut.—From Stonington Point to Norwalk.
8. Northern shore of Long Island.—From Montauk Point to Manhasset.
9. Southern shore of Long Island.—From Easthampton to Jamaica bay.
10. New York bay.
11. New York harbor.
12. East River.
13. East coast of New Jersey.—From Shrewsbury inlet to Cape May.
14. Delaware bay and river.
15. East coast of Delaware peninsula.—From Cape Henlopen to Cape Charles.
16. Chesapeake bay.
17. Coast of North Carolina.—From Currituck inlet to Cape Fear river.
18. Coast of South Carolina.—From Little River inlet to Savannah river.
19. Coast of Georgia.—From Savannah river to St. Mary's river.
20. Coast of Florida.—From St. Mary's river to Cape Florida.

The THIRD OR BIBLIOGRAPHICAL PART OF THE WORK gives, in a *first chapter*, a chronologically arranged list of the titles of the books which treat on the history, geography, and hydrography of the Eastern Coast, or of some part of it. To the titles of those books, with which I could make myself acquainted, are added a few critical notes, in which I have tried to point out their value and merit for hydrography. These notes are, however, omitted in reference to works which may be supposed to be generally known.

The *second chapter* contains a similar chronological list of the maps and surveys which have been made of the East Coast, or of parts of it.

About forty of these maps, which have a particular historical interest, have been selected, and reduced copies of them have been added, accompanied by historical notes on each particular map, showing the time of its composition, and pointing out its principal features and the progress of hydrographic knowledge visible upon it.

The task of giving a history of this coast had its peculiar difficulties, and needed much more research and labor than that of the Mexican Gulf and Pacific Coast. For though the Eastern Coast is better known than those, and though more has been learned respecting it, more also has been lost or forgotten. The explorations and surveys of the Pacific Coast have been executed in later times by scientific expeditions, and hence information respecting them is to be found in comparatively but few works, by the aid of which the history of discovery and the changes of names can be traced. On the Pacific Coast only two or three principal nations at the outset recognized the features of the country, and applied names to them derived from their own languages—the Indian aborigines, the Spaniards, and the Anglo-Saxons, (the Britons and Americans.) On the Eastern Coast, on the contrary, many different nations followed each other: the ancient Northmen, the Indians, the Spaniards, the English, French, Dutch, Swedes, &c. Each of these built up its own system of geography and information of the coast, to be afterwards modified or destroyed either partly or entirely by its successors. In consequence, it happened that old Indian names, wandering as it were from mouth to mouth, were in such a degree disfigured, that it becomes sometimes utterly impossible to trace their origin. Since the first quarter of the seventeenth century, a period of more than two hundred years, the hydrographic affairs of the coast, minute explorations, and the application of names, have been in the hands of numerous little communities, cities, States, State founders and colonists. As settlements followed or displaced each other, the names of places have accumulated. Old designations have been, in some cases, obliterated by new ones, and the records of their history have either been lost or scattered through the great mass of provincial and local documents yet extant in the archives of historical societies in different towns and State capitals along the coast.

In consequence of these and other circumstances, it happens that our information on the history of many points on the Eastern Coast is less complete and less certain than those on the Pacific or Mexican Gulf Coast. I have no doubt that much local information and historical tradition could be gained by resorting to each particular locality on the coast. This would, however, be the work of many years, if the lifetime of one individual would at all suffice for it. In the meantime, I have done what was possible under the circumstances, and hope I may be allowed to repeat here what a celebrated author said in concluding his work: "If in this work it shall be found that much has been omitted, let it not be forgotten that something likewise is performed."

With this essay on the hydrographic history of the Eastern Coast presented to you to-day, is now finished the work on the history of the coasts of the North American Union, for which I would propose the general title of Hydrographic Annals of the United States.

Yourself and others will be competent judges of the question as to its worth, and of the public interest involved in its publication.

* * * * * * * * * * *

I have, dear sir, the honor to be yours, most obediently and sincerely,

J. G. KOHL.

A. D. BACHE, LL. D.,
Superintendent U. S. Coast Survey.

APPENDIX No. 66.

Abstract of an historical account of explorations made on the coast of the Gulf of Mexico from the earliest times to the present.

[Prepared for the archives of the United States Coast Survey, by Dr. J. G. Kohl.]

WASHINGTON, D. C., *April* 17, 1856.

DEAR SIR: In conformity with your request to have prepared for the United States Coast Survey *a work on the history of the coasts of the Gulf of Mexico*, so far as they belong to the United States, similar to a historical description which I prepared and delivered in the preceding year relating to the Pacific Coast of the United States, I have now the honor and pleasure of sending to you the complete manuscript of the work in question.

According to the plan adopted for both, the entire work relative to the Gulf Coast is divided into three principal parts.

The *first or historical part* contains the history of the discovery and exploration of the Mexican Gulf Coast from the time of Columbus down to the present.

The *second* or more particularly the *hydrographic* portion contains a list or review of all the principal points and names occurring on the coast, with notes explanatory of each of them, and attempts at settling their orthography.

The *third* or *bibliographical* part contains chronological and critical lists of maps and books which relate to the Mexican Gulf Coast.

In the FIRST OR HISTORICAL PART I have tried to review and develop the whole maritime history of the Mexican Gulf in eight chapters, of which the *first* contains the early Spanish discoveries in the Gulf during the first part of the sixteenth century, and relates the manner in which the discoverer of the New World, Columbus—the circumnavigator of Cuba, Ocampo; the discoverer of Florida, Ponce de Leon; the first explorer of the Gulf Stream, Alaminos—and other heroic navigators, opened the gates and approaches of the Gulf; and how Grijalva, Cordova, Cortez, Garay, and others, navigated by degrees round its whole circumference, and settled the question of its being an enclosed part of the ocean.

This chapter further gives the history of the great land expeditions and conquests of the Spanish Generals Narvaez, Soto Luna, &c., so far as their expeditions had influence on the progress of discovery on the Gulf, and it shows, also, with how many interesting naval expeditions, which furthered this knowledge, they were combined.

In the *second chapter* I give the history of the first English travels and voyages to the waters and coasts of the Gulf of Mexico, after the middle of the sixteenth century, at the time of Queen Elizabeth and her naval heroes Hawkins, Drake, and others.

Those great expeditions of the Spaniards to the Gulf shores and these first attempts of the English navigators to enter the Gulf were, for different reasons, not soon followed by similar exertions. During more than a century the northern parts of the Gulf were much neglected, though the King of Spain, at different intervals, ordered better surveys of the coast to be made. The missionary cause, or misfortune by shipwreck, sometimes also became the occasions of voluntary or forced tours of exploration, and this gave to the world accounts of some parts of those regions then unknown. In the *third chapter* I have collected the history of these unconnected expeditions, these shipwrecks, these missionary tours and smaller travels, which were made either from Mexico or from the peninsula of Florida towards the northern regions of the Gulf, at the end of the sixteenth and during a greater part of the seventeenth century.

The discovery of the Mississippi by the French from Canada, and the appearance of the great French discoverer, La Salle, at the mouth of that river, (in the year 1682,) led at once to renewed efforts for the better exploration of the Gulf, and occasioned a series of different expeditions to its northern coasts, executed on one side by the French, who wished to take possession of these countries, and on the other side by the Spanish government, which wished to defend its ancient rights and pretensions. In the *fourth chapter* I have given the history of the first series of French expeditions to the Gulf; and in the *fifth chapter*, the history of those Spanish expeditions which were occasioned by them at the end of the seventeenth century.

The first attempts of the French ended unhappily, and the Spaniards remained in quiet possession of the Gulf. But with the beginning of the eighteenth century commenced a new series of more effectual French expeditions to the Gulf of Mexico. These induced, like the former, a new series of Spanish enterprises and of renewed efforts for exploration, conquest, and settlement. In the *sixth chapter* I have given the history of this second series of French expeditions; and in the *seventh chapter*, the history of the corresponding Spanish expeditions during the first quarter of the eighteenth century.

These latter expeditions ended in the division of the Gulf dependencies between France and Spain, who now both made permanent settlements. Through these and the different military, naval, astronomical, and geodetic operations, which were necessary in defining them, the whole Gulf and its principal features became better known. We may say that with those settlements the rough work of discovery and primary exploration ended, and the more minute and scientific research of the detail, and of every particular locality of the coast, commenced. In the *eighth chapter*, which contains the conclusion of our historical memoir, I have alluded to these minute researches and explorations of every part of the coast, and have given the reasons which induced me not to include them in my memoir on the history of the discovery, and why I preferred to relate what we know of them in the second part of the work under each particular name and locality.

The historical memoir is accompanied and illustrated by a *historical map of the Mexican Gulf*, in which I have tried to represent, in colors, the tracks and routes of the principal explorers and discoverers. On this map I have indicated their names, the dates of their expeditions, and the part of the coast which their expeditions covered. Besides this, to every principal bay, port, or river mouth are added also the names of those navigators and travellers who may be considered as having the principal merit in the better exploration of the point in question.

The SECOND PART of the memoir contains a series of historical notes or short essays on all the principal divisions of the Mexican Gulf and its different points, capes, islands, banks, bays, ports, and river mouths. The notes or essays are put in geographical order, beginning with the Cape of Florida, the easternmost point of the Mexican waters, and ending with the mouth of the Rio Bravo, the southwestern limit of the United States gulf shore.

According to the great natural division of the Gulf, we have divided this second part into five chapters:

The *first chapter* contains the points of the Florida gulf and keys from Cape Florida to Cape Sable.

The *second chapter*, the points and names of the west coast of the Peninsula of Florida from Cape Sable to Apalache bay.

The *third chapter*, those of the northern gulf shore from Apalache bay to the Rigolets, or the beginning of the Mississippi delta.

The *fourth chapter*, those of the Mississippi river and the shore of its great Delta, from the Rigolets to the River Mermentau.

The *fifth chapter*, those of the coast of Texas from the River Mermentau to the Rio Bravo.

The note or essay which is attached to each name gives a short sketch of the exploration of the point in question, and the history of its original name and subsequent changes. An effort is made, at the same time, to define the name which should be adopted and how it ought to be written.

In THE THIRD OR BIBLIOGRAPHICAL PART of the work, I give, in the *first chapter*, the titles of the historical, hydrographic, and geographical works which relate to the Mexican Gulf or parts of it, and which have been produced through the course of the last three and a half centuries.

These titles are put as much as possible in chronological order, and relating to those works, with which I could make myself acquainted, are added a few critical remarks, showing their value and degree of importance for the hydrographic knowledge and history of the Gulf.

In the *second chapter* of this bibliographical part is given a chronological list of all the hydrographic and geographical maps and surveys which have been made of the coasts of the Gulf or parts of them.

Of about forty maps I have appended reduced copies. This collection of reduced copies commences with the first indications of the Gulf in the old editions of Ptolemæus, and with the first rough sketch of the Gulf shores sent home by the Spaniard Garay in the year 1520, and concludes with the more modern representations of the Gulf by Humboldt and the hydrographic depot at Madrid. To every reduced copy of a map is added an explanatory note or essay, which gives the history of the map, so far as it is known to us, and points out the principal features, and the progress of knowledge observable on it; so that, by looking over these maps and notes, the reader may form to himself an idea how the Gulf was represented at different times, and how its hydrography was gradually developed from the discovery until our own time.

Yours, most respectfully and sincerely,

J. G. KOHL.

A. D. BACHE, LL. D.,
Superintendent U. S. Coast Survey.

APPENDIX No. 67.

Report on an index of reference to memoirs and papers on subjects related to the Coast Survey operations, by Lieut. E. B. Hunt, U. S. Corps of Engineers, Assistant U. S. Coast Survey.

NEWPORT, R. I., *October* 9, 1856.

DEAR SIR: In complying with your request of September 16, for a report upon the index of references now in progress, I propose to permit myself such latitude of treatment as the presentation of the subject appears to demand.

As an assistant in the Coast Survey, I had on various occasions to make some special researches on subjects of practical importance to the field and office work. The first desideratum in such cases was to ascertain the extent and character of prior analogous researches, and thus to establish sure bases of departure, so that I might proceed confidently to digest, recast, and amplify the ideas and facts pertaining to the subjects in hand. Experience and common sense alike testify to the folly of trusting solely to one's personal inspirations on important topics, without taking the pains first to establish an effective acquaintance with the recorded inspirations of those fine intellects which we may at the outset safely assume to have either touched or thoroughly investigated whatever subject may engage our studies. Themes are rare, indeed, on which the earnest thoughts and studies of many generations have cast no illumination. It is a most judicious rule, and one scarcely admitting of exceptions, by which an investigation, on taking up a new subject of study or research, is first of all remanded to a thorough review of whatever is already on record concerning this subject.

Here arises a great practical difficulty. The investigations on any subject of science are scattered through a vast number of series of transactions, memoirs, periodicals, annals, reports, special treatises, collected works, and irregular records. By what fine sense is the beginner or student of a special subject to single out from among the hundreds of thousands of miscellaneous papers on record the very limited number which are important to his immediate purpose? Is he to turn over the myriad volumes in which such papers may be imagined *a priori* to exist? Is he to sweep the whole domain of scientific records from the Almagest to Peirce's Analytical Mechanics? If so, he must begin a youth and end a Humboldt in years if not in knowledge. Yet, anything less than an actual sweep over all this vast range of records must leave the seeker somewhat uncertain as to his omissions. He is likely enough to pass unnoticed the very memoir most pertinent to his needs, and then this unknown judge will rise from its dust to convict him of labor in vain, or perhaps to accuse him of plagiarism, when ignorance or ill luck is the true extent of his offending.

The obvious and natural remedy for this difficulty is to *index all memoirs* and important papers under the subjects treated by each; to arrange all the titles of such records under duly assorted headings, and to bring those headings into a natural and easily accessible consecution, by so classifying subjects as to disentangle each speciality from all other generalities and specialities. True policy requires that a grand sweep of all these records of research should be made once and forever, and that a digested index should be formed by the systematic organization of all the titles thus gathered from all sources. This labor once done, it would be easy to extend the general index by the additions of each year. As the astronomer, by concerted arrangement, sweeps zone after zone of the celestial spaces, framing at first partial star catalogues, and finally one complete celestial sphere of star records, so may one complete catalogue ultimately give the co-ordinates of reference for every original or important paper on each scientific, economic, and artistic subject. This is a possible and most desirable result; but that it may be achieved, several competent persons must co-operate, libraries must be at command containing all needful series quite complete, and there must be a reliable wealth of means to sustain the workers through years of undivided toil for this one end. Meantime, men of science and investigators in all fields must grope on and serve themselves as best they can by the imperfect bibliographic aids now extant, and by partial realizations of the great and ultimate plan. The rapid yearly accummulation of scientific records will perpetually increase the already great need, until it will grow too unendurable to be borne, and then, if not before, the true remedy must be applied. All civilized nations are contributors to the perpetually growing mass of scientific leaves, and the rapid maturing of manifold sciences is already producing a class of special "old mortalities," whose function is to keep the present acquainted with the past. The noble memoirs of the Newtonian age are too full of matter to be forgotten in any coming age without damage to its manliness and vigor of mind.

There is now no index of memoirs at all approaching to completeness. Among the partial catalogues, one of the earliest and best is that prepared by the illustrious Dr. Young, in which references are given both to memoirs and separate treatises, and including abstracts of many of the papers cited. The whole extends to 434 quarto pages in the second volume of Young's collected works. It was published in 1807, and therefore lacks references for the prolific half century since that date. This catalogue is omitted in the late edition of Young's works. The *Repertcrium Commentationum a Societatibus Litterariis Editarum*, by J. D. Reuss, is far the most complete index of memoirs extant up to the dates of publications, its references being limited to memoirs. It is in sixteen quarto volumes of over five hundred pages each, the successive volumes having been published at Gottingen through the score of years succeeding 1800, and the physical volumes ranging from 1805 to 1808, so that this, like Young's index, is a half century behind our time. Each volume embraces one or more general subjects, thoroughly sub-classified, volumes 4, 5, 6, and 7 being on matters more or less pertinent to mathematical and physical science. The field of natural history is in part occupied by the work of J. Dryander, prepared as a catalogue of Sir J. Banks' library; but the great work of Agassiz, entitled *Bibliographia Zoologiæ et Geologiæ* has left zoologists and geologists little to desire except its supplements from year to year. The references gathered by Agassiz have besides been incorporated with additions by H. E. Strickland, and, under the editorship of the latter, published by the Ray Society in London; the first volume being dated 1848, and the last some two years since. This elaborate work includes references to treatises and memoirs, and is arranged under the names of authors. Dr. Schubarth has just published in Berlin, bearing the date of 1856, a Repertory of Technical Literature from 1823 to 1853, in which a vast number of references on subjects of Technology in all its subdivisions are distributed under subject headings. This product of thirty years' labor extends to 1,050 double column pages. Its materials are drawn only from magazines, journals, annals, &c., the transactions of learned societies being wholly omitted, and the interval of time covered leaving a great gap between Reuss and Young and this Technological Index. It is a specially valuable contribution to the aids for investigation, (especially of patentable matters,) and has relieved me of the need of turning through many volumes. I ought to mention Poole's Index to Periodical Literature, published in New York in 1853, and containing 523 double column pages. The contents of the leading popular and critical magazines are made easily accessible by this volume, under well-chosen subject headings; and though science forms but a small portion of the subject-matter, the work is of decided value even in this regard. I might specify numerous special indexes to particular scientific series, and some general indexes on branches foreign to the present purpose, but I know of nothing preventing the need of my completing the work on which I have been engaged. It will be seen, from what has been said, that the immense mass of records of physical science since 1800, is almost wholly without a *general* clue to its contents.

Hoping somewhat to aid this noble cause of scientific progress in our midst, but especially sure of giving essential aid to those various branches of practical and scientific pursuit involved in the diversified operations of the Coast Survey, I have expended considerable labor in gathering materials for a Classified Index of References to all-important detached papers on subjects directly or approximately involved in the present and future progress of this great national enterprise.

The organized operations of the Coast Survey bring under tribute a large portion of the arena of physical science, and over this extent it is a thing of almost daily consequence to this work that all existing records should be readily accessible. A clear perception of this fact led me to propose to you a special index of references for Coast Survey use. I need only remark, in this place, that the heartiness of your response to this suggestion was the most complete proof of the extent to which you had felt the need of such a grouping of references, and that the liberal facilities extended by you, and your patience with the delays consequent on the labor of the undertaking, and my divided public duties, will not be forgotten by me. I expected to finish within the year what has now consumed near three years. I began, little appreciating the extent of ground to be gone over. I have done what I could under my burden of engineer and light-house duties; and though I have essentially exceeded my original intent, both in time consumed and in extent of results gleaned, I am constantly more conscious of the imperfect character of the promised result. As I sweep through one series after another, selecting such titles as come within the prescribed limits, I find subjects, which at first I little regarded, swelling to substantive importance, so that the temptation to enlarge my bounds is one perpetually recurring. To pass by some treasure just adjoining my territory, never again to recall a title expressing some most interesting research, seems an ingratitude to the author, and an injustice to those who may expect from me some intelligence on this slighted theme. In truth, I just begin to feel myself fitted to begin this labor anew, and to do it thoroughly.

I am now drawing near the close of the list of series which I propose to examine. Some I must pass by as not sufficiently germaine to my object; some as already analyzed by Reuss and Schubarth, and others. Some, which I would gladly inspect, are not accessible in this country; and others, which embrace various real contributions to the special subjects on hand, are burdensome, fragmentary, and ill adapted for reference. I trust, during the coming winter, to shape my gleanings for the press. The result will be, on some accounts, too voluminous; on others, quite too little so. My object will be substantially accomplished, if, on trial, each person employed on the Coast Survey is able to say that its references serve his purposes. I venture to express the hope, also, that persons interested in geodesy, geography, navigation, hydrography, hydraulic engineering, physics of the earth and sea, practical astronomy, meteorology, electricity, magnetism, electro-metallurgy, photography, optics, themics, meteorology, the graphic arts, printing, technology and general physics, and many other minor subdivisions of science and art, will find some useful references, though certainly not all they may desire. It will not be at all a reference index for separate treatises, and for these the existing bibliographical apparatus must still be used. This field is quite well presented in such catalogues as Englemann's, Murhard's, Brunet's, Kayser's, Bossange's, Appleton's Library Manuel, &c.; while, for academic transactions, I know of nothing more complete than Part I of Agassiz and Strickland's Bibliographia, and nothing so convenient as the lists in Dr. Cogswell's Astor Library Catalogue.

It would be ungracious in me here to omit an expression of thanks for the uniform courtesy and assistance extended to me at the several libraries I have had occasion to visit. I have used the facilities afforded by the Congress, Smithsonian, Engineer Department, and Coast Survey libraries in Washington, the Astor library in New York, Brown University library in Providence, the Athenæum and American Academy libraries in Boston; and I soon expect to examine some series in the Boston city library rooms. The Boston Athenæum and the Astor libraries have been of especial service for the extent and completeness of their series of transactions. The Astor library, despite its Minerva-like birth, has fewer gaps than any other, and is indeed so fully realizing the hopes of its friends that I feel safe in denominating it the best library of reference in our country, and better, in fact, than some possessing a much larger number of volumes without selection.

Mr. Charles A. Schott, of the computing division, has examined some German series, as a co-laborer, in so satisfactory a manner that I particularly hope he will be enabled to complete those yet remaining.

I subjoin a list of the series hitherto examined, in whole or in part, with brief titles. This report, though utterly unworthy the subject, must now suffice. My engineer duties at Fort Adams, and my charge of light-house constructions in the Rhode Island subdivision, have left me little leisure during the past season to bestow on the consummation of my appointed Coast Survey work. To this fact the present report owes somewhat of its discursive and incomplete character.

Very respectfully, yours, &c.,

E. B. HUNT,

Lieut. Corps Engineers, Assistant Coast Survey.

Prof. A. D. BACHE, *Superintendent U. S. Coast Survey.*

List of series of Transactions, Journals, Reports, &c., examined for the Coast Survey Reference Index, prior to October 9, 1856.

AMERICAN SERIES.

	VOLS.
American Association for the Advancement of Science	6
American Philosophical Society Memoirs	15
American Academy Memoirs	9
Smithsonian Contributions	6
American Astronomical Journal	4
American Almanac	23
American Nautical Almanac	2
American Journal of Science	66
Franklin Institute Journal	60
Appletons' Mechanics' Magazine	3
Hunt's Merchants' Magazine	34
De Bow's Commercial Review	21
North American Review	74
American Quarterly Review	21
Southern Review	6
New York Review	6
American Whig Review	16
Harpers' Magazine	9
Putnam's Monthly	4
Public Documents of the Senate and House of Representatives, 1831–'32 to 1853.......say	250
Total American	645

BRITISH SERIES.

British Association Reports	22
Philosophical Transactions	142
Transactions Cambridge Philosophical Society	7
Transactions Royal Society, Edinburgh	15
Transactions Royal Irish Academy	22
Memoirs and Notices of London Astronomical Society	31
British Nautical Almanac	71

	Vols.
Journal Royal Geographical Society, London	23
Transactions Bombay Geographical Society	2
Hakluyt's Voyages and Hakluyt Society Publications	18
Asiatic Researches	20
Transactions Institution of Civil Engineers	3
Royal Engineer Papers	12
Weale's Quarterly Papers on Engineering	6
Transactions Society of Arts	56
Taylor's Scientific Memoirs	5
Cambridge and Dublin Mathematical Journal	6
Journal London Statistical Society	17
London Repertory of Arts and Manufactures	26
Tilloch's and London, Edinburgh, and Dublin Philosophical Magazine	119
Jameson's Philosophical Magazine	54
Brewster's Edinburgh Journal of Science	16
Nicholson's Journal	41
Nautical Magazine	25
North British Review	24
Transactions Geological Society	6
Art Journal	18
Total British	807

FRENCH SERIES.

Memoirs of the Academy and Institute	204
Comptes Rendus	42
Connaissance des Temps	61
Academic Collections	29
Liége Academy Memoirs	9
Memoirs of the Royal Society of Sciences of Lille	16
Gergonne's Annals of Mathematics	17
Terquem & Gerono's New Annals of Mathematics	13
Journal of Mathematics	20
Journal of the Polytechnic School	35
Annales de Physique et de Chimie	163
Memoirs of Annales des Ponts et Chaussées	49
French Patent Specifications	82
Memorial de l'officier du Génie	16
Memorial de l'Artillerie	5
Memorial du Depôt de la Guerre	7
Bulletin of the Paris Geographical Society	65
Rozier's Observations	89
Total French	922

BELGIAN SERIES.

	VOLS.
Memoirs of Brussels Academy	55
Annals of the Universities of Belgium	6
Quetelet's Mathematical and Physical Correspondence	11
Bulletin of the Brussels Museum of Industry	25
Annals of the Public Works of Belgium	14
Total Belgian	111

MISCELLANEOUS.

Memoirs of Geneva Physical and Natural History Society	13
Memoirs Society of Natural History, Neufchatel	3
Batavian Academy Memoirs	20
Leipsic Transactions	2
Turin Academy Memoirs	48
Berlin Academy Memoirs	77
Lisbon Academy Memoirs	14
St. Petersburg Academy Memoirs and Bulletins	84
Memoirs Royal Society of Northern Antiquarians, Copenhagen	5
Kupffer's Meteorological Correspondence, St. Petersburg	2
Astronomische Nachrichten	42
Poggendorf's Annalen	66
Berlin Astron. Jahrbuch	38
Memoirs Göttingen Society	37
Berlin Geographical Society Proceedings	4
Gumprecht's Geographical Journal	5
Vienna Academy Transactions	13
Grunert's Mathematical and Physical Archives	6
Transactions Bavarian Academy, Munich	16
Gilbert's Annals of Physics	76
Miscellaneous publications	41
Total miscellaneous	612

General aggregate of volumes examined 3,067

E. B. HUNT,
Lieutenant Corps of Engineers.

APPENDIX No. 68.

On systematizing the abbreviations of titles of periodicals, transactions, &c., by Lieutenant E. B. Hunt, U. S. Corps of Engineers.

NEWPORT, R. I., *August* 23, 1856.

DEAR SIR: In preparing, under your direction, an index of titles of papers on subjects involved in the operations of the Coast Survey, gathered from all the scientific periodicals, transactions, memoirs, &c., to which I can obtain access, one unanticipated difficulty has again and again perplexed me. Every title which I take out must contain an abbreviation of the title of the work from which it is taken; hence I have been obliged to write many thousands of these abbreviations while gathering the materials for this Coast Survey Index. It is therefore a matter of considerable moment that these abbreviations should be as brief as possible, while serving their primary purpose. The special difficulty to which I refer is, that there is no authentic code of abbreviations in general use, and that many of those particular forms which I have encountered are long, unwieldy, indeterminate, and conflicting. In many instances I have to coin abbreviations, and in many others there are insuperable objections to such as are now more or less in vogue. This subject is more important than it might at first appear; for these abbreviations are not only written and printed thousands of times each year, but every cultivator of science must, as a part of his special training, become familiar with the abbreviations which concern his own departments of research, as a kind of special alphabet. Hence the abbreviated forms ought to be as short as possible, without losing distinctness, to save needless writing and memorizing. This will be better appreciated when we bear in mind that the list of Agassiz and Strickland contains 1,284 titles of acts, journals, and collections of papers on zoology and geology alone, without being complete, even on those subjects; while each of these titles must probably have one or more abbreviations in use. We ought not to forget that we are even now but at the beginning of scientific expansion, and that each succeeding year is bringing into being accessions to the long array of scientific records. It is therefore of the greatest prospective importance that principles for abbreviating titles should now be settled, and that practice should as rapidly as possible be brought to a uniformity based on these principles. In 1856 we should bear in mind that the year 2000 is to come, and that then the records of science will be found under at least a myriad of separate periodical titles, and each series will contain matters for reference, as now we refer to the *Academia del Cimento;* records of the French Academy for French scientific issues; the German Association of Naturalists and Physicists for German issues; the St. Petersburg Academy for Russia; the Italian Scientific Association for Italian issues, &c. The results, on being aggregated, would doubtless make a proper subject for publication by the Smithsonian Institution. It seems to me that some plan of this general character would be feasible. Should the American Association share this impression, it is in its power to initiate the measure, and test its practicability, with no fear of bad results. The demand of coming generations will be for freedom of memory, and our duty is to make their memoric burdens a minimum. I will cite here a few instances, and these not the worst, to show how unsettled and chaotic our existing practice of abbreviation is.

The American Journal of Science is abbreviated to—

Am. J. Sci.........by Prof. Dana, one of the editors.
Am. J., *Amer. J.*, *Amer. Jour.*, by Agassiz and Strickland, in the Index.
Jour. of Sci.........by Poole, in his Index.
Sill. Am. J..........by Liebig and Kopp, in Annual Report, &c.
Sillim. J.............by Dr. Schubarth in his New Repertorium.

The Philosophical Transactions of the Roy. Soc., London, are abbreviated—

- Phil. Tr., / Phil. Trans., by Agassiz and Strickland.
- Philos. Transact...by Reuss, in his Repertorium.
- Ph. tr................by Dr. Young, in his Index.

The Comptes Rendus, as follows:

- Compt. Rend.........by Liebig and Kopp.
- Compt. r...............by Schubarth.
- C. r., / C. R., / Comptes Rendus / Compt. Rend., by Agassiz and Strickland.

The French Academy and Institute Memoirs are thus abbreviated—

- Mém. de Paris, by Preuss.
- A. P. / S. E. by Young.
- Mém. Acad. Sc. Par., / Mém. Acad. des Sc., / Mém. Sav., etc., / Mém. prés. à l'Acad., by Agassiz and Strickland.
- Mém. Inst. is common for the later memoirs.

This chaotic diversity is common to nearly all abbreviations in the above cited works, where they must have received rather special deliberation; and by referring to individual modifications, by separate investigators, a perfect Babel of usage will be found. That this is a real evil, I assume none will question. Can it be corrected, is a question on which different opinions will probably be found to exist. Certainly, correction cannot come without some effort, and without the aid of time. There is time enough; there ought to be effort enough. Things cannot be worse, for there is now nothing fixed. Conservatism has nothing to fear in this instance. It has occurred to me, as a plan which would stand a respectable chance of success, for the American Association to initiate a reform by consigning the subject to a special committee with instructions to invite, in behalf of the Association, the co-operation of other countries concerning their own periodicals, &c. Thus, for instance, the American Association for the Advancement of Science might fix such abbreviations for all American scientific issues. It might, by correspondence, invite the co-operation of the British Association, or Philosophical Society for British periodicals, &c.

Some principles of abbreviation might here be elaborated, but I shall only say, in brief, 1st. That abbreviations should be as brief as possible, without becoming obscure. The motto should be "abbreviations that are abbreviations." 2d. Only the leading characteristic words of a title should find place in an abbreviation. Connecting particles should be thrown out. The possessive or genitive form, which is by far the most frequent, can be easily disposed of by using the apostrophe or possessive sign for *of* or *of the*, thus: Am. J. Sci.—J. ' Soc. ' Arts. 3d. Certain words of very frequent occurrence should be reduced to their initial as an abbreviation, as J. for Journal, M. for Memoirs, N. for New, Nouvelle, Nuovo, Neue, Nova; others to two initials, as Ph. for Philosophical, Tr. for Transactions, An. for Annual, Ac. for Academy, &c. In general, the same word, when frequently occurring, should be constant, and a practical minimum in all combinations, and, when possible, in different languages. 4th. Location should, as a general rule, enter each abbreviation in some form, as M'. Ac'. Par., for the Paris Academy Memoirs; Am. Ph. Tr., American Philosophical Transactions. These hints will suffice to show that there are principles in this matter which should be carefully elaborated and weighed.

It may be that the coinage of abbreviations under compulsion, which has fallen to my lot, leads me to attach an undue importance to the subject; but I am confident that a like experience would make most persons quite as desirous of seeing an *established code of abbreviations for all the world,* as I have been.

Very truly, yours, &c.,

E. B. HUNT,
Lieut. Corps of Engineers.

Professor A. D. BACHE,
Superintendent Coast Survey.

APPENDIX No. 69.

Letters to the Secretary of the Treasury, transmitting a communication from Lieut. Comg. S. D. Trenchard, U. S. N., Assistant in the Coast Survey, relative to the rescue, by his party, of the British barque "Adieu," and testimonial from the consignees relative thereto.

ALBANY, *August* 25, 1856.

SIR: I have the honor to transmit herewith a copy of a communication from Lieut. Comg. Stephen D. Trenchard, U. S. N., assistant in the Coast Survey, stating particulars of the rescue of the British barque *Adieu,* found in a sinking condition by his party in the surveying steamer Vixen, while engaged in the prosecution of hydrographic work on the coast of Massachusetts.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

U. S. COAST SURVEY STEAMER VIXEN,
Gloucester, Mass., August 14, 1856.

DEAR SIR: I have the honor to report that at noon to-day, in passing the Sunken Salvages, we fell in with the British barque Adieu, from Glascow, bound to Boston, laden with railroad iron and sugar, and in a sinking condition—her officers and crew much exhausted from constant labor at the pumps.

I placed Mr. Morrison, master, U. S. N., and a party of men on board the barque—with buckets &c., took her in tow, and succeeded in bringing her in safety to this port.

Great credit is due to the efficient services and strenuous efforts of Mr. Morrison and his party, through whose exertions, by pumping and bailing, the Adieu was kept afloat until towed by the Vixen into port.

I am, very respectfully, your obedient servant,

STEPHEN D. TRENCHARD,
Lieut. Comg. U. S. N., and Asst. Coast Survey.

Professor A. D. BACHE,
Superintendent U. S. Coast Survey, Washington.

UNITED STATES COAST SURVEY STATION,
Near Ellsworth, Maine, September 22, 1856.

SIR: I have the honor to enclose herewith a copy of a communication bearing testimony to the services of Lieut. Comg. S. D. Trenchard and the officers of the Coast Survey steamer Vixen, in towing into Gloucester, Mass., the British barque Adieu, found in a sinking condition off Cape Ann.

Yours, respectfully,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

BOSTON, *September* 12, 1856.

SIR: We beg leave to make known to your department our sincere thanks for the highly important services rendered to the British barque Adieu, P. S. Corbett master, by the United States Coast Survey steamer Vixen, under charge of Lieut. Comg. S. Decatur Trenchard, on the 14th of August last; said barque was in a sinking condition, near Cape Ann, when the Vixen took her in tow and got her safely into Gloucester.

The conduct of Lieut. Trenchard and his officers and crew merits our warmest commendations.

Very respectfully, your obedient servants,

ISRAEL, LOMBARD & CO.,
Consignees of British barque Adieu, and Agents for Insurance Companies at St. John's, N. B.
FRANCIS BACON,
President China Mutual Insurance Company.
JAMES STURGES,
Agent of Lloyds.

Professor A. D. BACHE,
Superintendent Coast Survey, Washington, D. C.

BOSTON, *September* 10, 1856.

DEAR SIR: I enclose herewith copies of letters received from E. A. Grattan, Esq., Her Britannic Majesty's consul at this place, the master, consignee, underwriters, and others, connected with the British barque Adieu, acknowledging the services rendered by the Coast Survey steamer Vixen to that vessel while in a sinking condition, off the Salvages, near Cape Ann, on the 14th instant, a report of which I have previously made to you.

I am, very respectfully, your obedient servant,

STEPHEN D. TRENCHARD,
Lieut. Comdg. U. S. N., and Asst. Coast Survey.

Professor A. D. BACHE,
Superintendent U. S. Coast Survey.

BRITISH CONSULATE, BOSTON, *August* 20, 1856.

SIR: Having seen, in the Boston papers of this date, a card, signed by the master, consignees, and underwriters of the British barque Adieu, tendering their thanks to yourself and the officers and crew of the vessel under your command, for the valuable assistance afforded by you to said barque, while in a sinking condition off Cape Ann, on the 14th instant, I beg to add thereto the expression of my own thanks, in acknowledgment of the efficient services rendered by you on the occasion referred to. It will give me much pleasure to represent to her Majesty's Government the friendly conduct of yourself and officers in this matter, and I have the honor to be, sir,

Very respectfully, your obedient servant,

EDMUND A. GRATTAN,
Her Majesty's Consul.

Lieut. Comg. S. D. TRENCHARD, U. S. N.,
U. S. Steamer Vixen, Ipswich, Mass.

BOSTON, *August* 20, 1856.

SIR: We beg to offer to yourself, and to the officers and crew under your command, our hearty thanks for the prompt and efficient services rendered to the British barque Adieu, when in great danger of being lost, near Cape Ann, on the morning of the 14th instant. With sentiments of personal respect, we remain,

Your obedient servants,

P. S. CORBETT,
Master British barque Adieu.
ISRAEL, LOMBARD & CO.,
Consignees of British barque Adieu, and Agent for the New Brunswick Marine Insurance Company.
JAMES STURGES,
Agent of Lloyds' and British Underwriters.
FRANCIS BACON,
President China Marine Insurance Company.

Lieut. Comg. S. D. TRENCHARD,
U. S. Coast Survey Steamer Vixen.

APPENDIX No. 70.

Letter of the Superintendent, transmitting report of the Commission, called at the request of the Hon. Secretary of the Navy, to investigate the causes which led to the explosion of a boiler of the Coast Survey steamer Hetzel, in August, 1855.

NEW YORK, *November* 26, 1855.

SIR: I have the honor to acknowledge the receipt of your communication of September 12, enclosing copy of a letter from the Hon. Secretary of the Navy, requesting that an investigation should be made to ascertain the causes which led to the explosion of the boiler of the surveying steamer Hetzel.

In accordance with the request from the Navy Department, a commission, consisting of Commander H. S. Stellwagen, U. S. N., Charles W. Copeland, Esq., consulting engineer, and First Assistant Engineer W. Holland, U. S. N., met at Baltimore, on board the steamer Hetzel, on the 16th, 17th, 19th, and 20th of November instant; and I enclose herewith their joint report, made after examination of the wreck of the boiler, and in connection with the testimony of persons who were on board the Hetzel at the time of the disaster.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

NEW YORK, *November* 6, 1855.

SIR: By direction of the Treasury Department, and at the request of the Hon. Secretary of the Navy, an investigation will be made into the causes and circumstances which led to the explosion of the boiler of the Hetzel.

You are hereby detailed as a member (senior member) of a commission to make the above investigation. Your colleagues are Charles W. Copeland, Esq., consulting engineer, and First Assistant Engineer William Holland, U. S. N.

You will please proceed to Baltimore, and meet your colleagues on board of the steamer Hetzel there, on the 13th day of November. Lieutenant Commanding Almy has instructions to furnish you the necessary facilities for meeting and for discharging the duty entrusted to you, and to retain the officers and men of his party together, in case they should be needed as witnesses.

On the close of the investigation of the commission, please report to me the results, jointly with your colleagues.

Yours, respectfully, &c.,

A. D. BACHE,
Superintendent United States Coast Survey.

Commander H. S. STELLWAGEN,
United States Navy, Assistant Coast Survey.

I certify the above is a true copy, and that orders to the same effect were addressed to Charles W. Copeland, Esq., and Mr. Holland, first assistant engineer, U. S. N., varied slightly in the second paragraph.

H. S. STELLWAGEN,
Commander United States Navy.

Proceedings of a "commission of investigation into the causes and circumstances which led to the explosion of the boiler of the Hetzel," held on board the United States Coast Survey steamer Hetzel, in the month of November, 1855, by order of Professor A. D. Bache, Superintendent United States Coast Survey, (issued by direction of the Treasury Department, and at the request of the Hon. Secretary of the Navy,) a copy of which is appended:

The commission met, in pursuance of directions of Professor A. D. Bache, Superintendent Coast Survey, at Baltimore, Maryland, on board the Coast Survey steamer Hetzel, on the 13th day of November, 1855. Members present—Commander H. S. Stellwagen, U. S. N., and First Assistant Engineer William Holland, U. S. N.; Charles W. Copeland, Esq., consulting engineer, not present.

At 1 p. m. adjourned, to meet again on the 14th of November, at 9 a.m.

On the 14th, met at 9 a. m., and received a communication from Charles W. Copeland, Esq., a member of the commission, stating that he was unavoidably detained as a witness before the United States circuit court, in the city of New York. Adjourned at 12 m., to meet again at 9 a. m. on the 15th.

November 15.—Met at 9 a. m. Charles W. Copeland, a member of the commission, still absent. Adjourned at 12 m., to meet on the 16th November.

Friday, November 16, 1855.—The commission met, in pursuance of adjournment. The senior, acting as president. Members all present, viz: Henry S. Stellwagen, commander United States Navy; Charles W. Copeland, Esq., consulting engineer; William Holland, first assistant engineer, United States Navy.

The board then proceeded to business, and it was decided, after a preliminary examination of the wreck of the boiler and vessel, to take the evidence of those of the officers and crew whose testimony might throw some light upon the subject under investigation. There being no member of the commission legally empowered to administer oaths, that preliminary was dispensed with.

The following witnesses were called and examined in the order named:

November 16— 1. J. J. Almy, Lieut. Comg., U. S. N.
2. Stephen B. Minor, Pilot.
3. Charles H. Williamson, Passed Assistant Surgeon.
4. Charles P. McGary, Lieutenant, U. S. N.

November 16— 5. J. T. Little, Carpenter's Mate.
6. Albert Allmand, Lieutenant U. S. N.
November 17— 7. R. H. Walton, Coal-heaver.
8. B. F. Van Horn, Second-class Fireman.
9. R. L. Nelson, Second-class Fireman.
10. Andrew DeVeau, First-class Fireman.
November 19—11. John Bunting, First-class Fireman.
12. William C. Wheeler, Second Assistant Engineer U. S. N.

The board met daily, except Sunday; on the 16th, 17th, and 19th took evidence of the witnesses, and on the 20th examined fully and carefully the wreck of boilers and vessel, obtaining all information regarding any changes in the same since the accident, and beg leave to make the following report:

1st. Cause of the accident.

After a careful consideration of the evidence, and a thorough examination of the remains of the port boiler, we have concluded that the immediate cause of the accident was the closing of the steam stop-valve upon it, on the evening of the 23d of August, with a view of more thoroughly cooling that boiler preparatory to making the repairs, and that this valve was forgotten and neglected on the morning of the 24th of August, and the steam having no other outlet (there being no safety-valve on this boiler) the internal pressure of steam increased until it was too great for the resisting powers of the boiler, and an explosion was the consequence.

Further, we are well aware, from examination and testimony of witnesses, that the boilers were old and weak; but had they been new and strong, it could only have affected the result so far as a remote probability that a very little further time before the explosion might have given a slightly increased chance of its attracting the attention of some one to the fact of its being closed, and giving them an opportunity to open it in time to relieve the boiler, and thus avoid the accident; but, on the other hand, had the boilers been thus new and strong, and the stop-valve not opened, it must have eventually exploded, and the results would have been much more disastrous.

2d. The nature and course of rupture of the boiler.

The leak first started about point X, upon the drawing accompanying this report, (see Sketch No. 67,) at which place the iron is in thickness about No. 3 wire gauge. The rupture, however, appears to have commenced at the bottom of the boiler, near point P upon the drawing. The after or front end of the shell of the boiler, with steam drum, was torn from head sheet and thrown upwards and forwards, tearing asunder nearly in the direction shown by the line L L, &c., in the drawing, the forward or back part of boiler remaining comparatively undisturbed and uninjured. Several places along the line of rupture were gauged by us, and were found to vary in thickness from No. 6 to No. 10 wire gauge.

The order of the explosion we judge to have been thus: all around the furnace, through the water space, the legs were braced by screwed brace bolts tapped into shell and furnace sheets, and slightly riveted on the ends by cold riveting. The heads or riveting of all these brace bolts were more or less rusted away, and in many cases the threads were also rusted. When tapped into sheets, these bolts appear to have first drawn through the sheet, the furnace sheets collapsing, and the shell expanding, until ruptured just at point P in the drawing, as already explained.

That portion of the boilers back of the furnaces was braced by riveted braces and socket bolts, and when the longitudinal rupture arrived at these braces, they appear to have been sufficient to resist the strain, and the line of rupture then took an upward and forward course, as already described

This is not the first case of accidents of a fatal character having occurred from this same cause—the insufficiency of the screw brace bolts, particularly after being for a length of time in use and subject to oxidation, &c. We desire to express, in the strongest manner, that, in our opinion, braces of this description should not be permitted in the construction of steam boilers, where they will be subjected to the action of salt water, or from other causes liable to rapid oxidation.

3d. The improper arrangement of appurtenances to the boilers.

One of the causes which remotely has led to this accident is, in our opinion, the very improper arrangement of the appurtenances.

With but one safety-valve, and that on the main steam-pipe, arranged as shown by the accompanying drawing at K, the shut-off steam valves ought, instead of being screw valves, to have had plain stems, so as to have been self-acting; had they been thus made, as soon as the pressure within the port boiler was greater than in the starboard one, the stop-valve would have been opened by the excess of pressure and the boiler relieved. Again: If it was deemed necessary, from any cause, that the stop-valves *should* be screw-valves, then, instead of there being but *one* safety-valve upon the main steam-pipe, there should have been one upon *each boiler:* in which case, the stop valve being neglected, the boiler would be relieved by the safety-valve.

It will be seen, by reference to the accompanying drawing showing the arrangement of the boilers, that the screw-stop-valve being shut, and the safety-valve upon the steam-pipe unable to relieve the boiler, there being, also, no safety-valve or other outlet for steam from the boiler, except through this stop-valve, the safety of those on board depended entirely upon the thoughtfulness and vigilance of those connected with the engineer department, as there was no possible way in which the boiler could be relieved of the increasing pressure of steam but by rupture.

Had there even been a steam-gauge connected with each boiler, independently, it would have greatly added to the safety of the whole arrangement, as the difference of pressure indicated by the several steam-gauges would have attracted attention, and the error or neglect have been corrected in time to avoid the disastrous result. In fact, there was, by the arrangement of the appurtenances to the Hetzel's boilers, no possible way in which they could be relieved by any automatic action of any of those appurtenances. Nor was there any way provided by which the dangerous condition of the boiler could be indicated to the eye or ear, or in any way brought to the notice of the attendants. We cannot but condemn, in the strongest terms, such improper, injudicious, and unsafe arrangements, and have no doubt that had they been such as we have stated above as desirable, we would not have been called upon, by so serious a disaster, to record at this time these opinions, or report upon this accident.

4th. The probable cause and circumstances which, combined, led to the accident.

That the cause of the explosion could not have been *low water* in the boiler, is shown by the testimony of all the witnesses who *could* testify upon that point. (See testimony of Wheeler, De Veau, Nelson, Bunting, and Walton.)*

That there was not a gradual increase of pressure on *both* boilers, until the port boiler, being the weakest, gave way, is evident from the fact that the highest pressure on that morning, testified to by every witness, is 29 pounds; and it would appear, by a proper consideration of all the evidence, that the maximum was not over 23 to 26 pounds, whereas there had been previously 30 carried in several instances. This is the more strongly confirmed from the present condition of the starboard boiler, which shows no indications of yielding, straining, or weakness. (See Mr. Wheeler's testimony, also Nelson, Bunting, De Veau, and Mr. Allmand.) And, further, it is shown that there was no delay in getting under way, and therefore no probability of such increased pressure.

Again: that it could not have been caused by a malicious or vindictive tampering with shut-off valves, we think to be clearly shown by the universal good feeling existing between officers and men, as fully and clearly testified to by every witness. Further: there was a standing order that no one should enter the boiler-room (where the shut-off valves were) but those

* Omitted.

belonging to the engineer department; and it is in evidence by Mr. Wheeler that he had punished but one man of the engineer department this season, and had punished him but once, several weeks previous, by making him stand an extra watch; that this man could not have tampered with the valve is clear, from the fact that he was in the most exposed position when the accident occurred, viz: in the fire-room, washing clothes, although not his watch at the time, and hence *voluntarily* in this exposed condition.

Having thus narrowed down the probable cause of the explosion to the fact of the stop-valve on the port boiler being closed, *in the regular course of duty*, and not again opened previous to getting up steam, we will now explain what, in our opinion, was the order of circumstances by which the disastrous result was brought about.

It appears (see testimony of Wheeler) that, on the evening of the 23d of August, Mr. Latimer was anxious to make the repairs to the port boiler that night, but the boiler was too hot; that in conversation with Mr. Wheeler, he (Mr. W.) suggested that, by closing the steam stop-valve, so as to shut off the heat from the starboard boiler, the port boiler would be rendered more comfortable and cool more rapidly; Mr. Latimer then left Mr. Wheeler, was gone a few minutes, and returned to Mr. W., saying the boiler was too hot, and he would leave the repairs till morning.

We suppose that at this time, when Mr. L. left Mr. Wheeler, he went and directed the stop-valve to be closed, to learn if by so doing the heat of the port boiler would be so far reduced as to enable them to make the repairs. Finding that the closing of the valve did not produce the beneficial effect anticipated, he returned to Mr. Wheeler to report it to him, *without having re-opened the valve.*

The next morning, in the hurry and bustle of making the repairs, and getting the vessel under way, the fact of the valve being closed the evening previous was entirely forgotten. Bulger, who aided in making the repairs, was relieved from his watch at 8 a. m., at which time the leak had not yet broken out, (see testimony of Wheeler;) finding, after he (Bulger) came off watch, that the forward man-hole plate was leaking, he went down the fire hatch to screw it up, (see testimony of Nelson and De Veau,*) and about this time the leak broke out. Bulger then came up and went aft, on the port side, and was last seen alive near the entrance to the boiler room on the port side, (see testimony of Nelson;) we suppose that it had occurred to Bulger's mind that the valve was shut, and when last seen alive he was about entering the boiler room to examine the valve, (see testimony of De Veau and Nelson,*) and if so, he was probably on the top of the boiler, but had not time to open the valve before the terrible catastrophe occurred which so suddenly deprived him of life, (see testimony of De Veau.)

Such, in our opinion, was the order in which the circumstances occurred. There is but one point in the testimony that appears to conflict with this theory: it is the remark made by Bulger, in the presence of Mr. Wheeler and Mr. Latimer, and also repeated to Nelson, "that the steam would pass through the connecting pipe, from one boiler to the other, and thus there would be no difference in the time of getting up steam" in the two boilers, (see testimony of Wheeler and Nelson.*) The inference to be drawn from this is, that Bulger was confident the stop-valve was open, or that he knew that it had been shut and he intended to open it, or thought he had already opened it. The repeating of this remark by Bulger would lead to the opinion that his attention had been specially called to it during the repairs.

With the evidence elicited before us, this theory can only be modified as to the *time* of the valve being closed; that, instead of its being closed the evening before, it might have been closed by Bulger in the morning, after he had commenced work on the boiler, as it is testified by Bunting that he (Bulger) suffered much from the heat in the boiler and *came out once* before the work was completed; it is not improbable that, on account of the heat being so great, he may *at that time* have closed the valve to shut the heat from the starboard boiler.

* Omitted.

The supposition that Bulger did go into the boiler room for the purpose of opening the steam stop-valve is strongly sustained by the fact of the valve being found about one-quarter of an inch open, upon examination in the afternoon of the day on which the explosion occurred. (See testimony of Bunting.)

One circumstance we should mention, as showing the position of the shut-off steam-valves at the time of the explosion, is, that the stem of the starboard valve is bent upward for about eight or nine inches of its length, showing that it projected that distance beyond the crossbar at the time of the explosion; whereas the port valve stem is only bent for about three inches of its length, showing conclusively that the valve must have been screwed shut, or nearly so, at the time of the accident.

From the testimony of the witnesses, there can be no doubt that those men who were killed, belonging to the engineer department, were very capable, industrious, and efficient men, more especially Gardner and Bulger; the latter is spoken of by Mr. Wheeler as a very excellent man in these respects, not only in performing thoroughly his watch duties, but being at all times very attentive and reliable—ready for any work that appeared necessary.

Mr. Wheeler testified in the strongest manner to the ability and efficiency of Mr. Latimer, the assistant engineer, and the alacrity and vigilance with which he attended to his duties; and all the officers pay a just tribute to the fortitude and heroism displayed by him subsequent to the explosion, when suffering the most intense bodily pain, and knowing that he could live but a very short time.

The notes of the evidence taken from the several witnesses named,* and also a sketch or drawing of the boilers and appurtenances, are forwarded herewith, for the further information of the Department. (Sketch No. 67.)

Having thus traced the causes of the accident to the neglect or forgetfulness of the duty of opening the stop-valve, it may be required to know the amount of culpability, and on whom it may rest. These points can never be fully explained; and though the effect was so sadly disastrous, yet it must be borne in mind that no positive order had been issued to close the valve; that it had not been customary, and in fact had not been done before during the whole season; and hence that such forgetfulness was more probable and excusable.

The suggestion to close the stop-valve may have been made or repeated in presence of William Bulger, who is represented as a highly capable, industrious, and willing man, with a reliance that he would attend to it fully, as well in opening again as closing it, it being a simple act of duty, or he might have closed it of his own accord to facilitate the repairs; let this be as it may, whoever was in fault, he or they have paid the penalty, either in loss of life or in mental anguish, more than commensurable with so involuntary an offence.

The engineer in charge, Mr. Wheeler, appears to have taken a very commendable and unusual precaution against accidents generally, and particularly against ignorance of the use or unskilful manipulation of these stop-valves, as shown by the evidence of his instructing his firemen in their objects and modes of use. His general attention to duty is fully established, and his conduct on this occasion has elicited the admiration of officers and men.

The commanding and other officers and crew generally displayed self-possession and good conduct throughout, and a feeling of sympathy and kindness for the injured, which redounds to their honor.

Having thus performed the duty assigned to us, we respectfully submit the foregoing report.

H. S. STELLWAGEN, *President.*
CHAS. W. COPELAND, *Consulting Engineer.*
W. HOLLAND, *First Assistant Engineer, U. S. N.*

BALTIMORE, *November* 21, 1855.

* Omitted.

APPENDIX No. 71.

Report of Assistant A. M. Harrison, on the circumstances attending disaster to the surveying schooner Benjamin Peirce, by the drifting to her quarters of the burning steamer Seminole, at Jacksonville, Florida.

UNITED STATES SCHOONER BENJAMIN PEIRCE,
Off Jacksonville, East Florida, January 7, 1856.

DEAR SIR: I send you the report of Mr. Hawley to myself, of all the occurrences connected with the Peirce up to the day of my arrival here. After reading this report, and instituting a thorough inquiry into all the circumstances connected with the unfortunate disaster which occurred to the Peirce by the burning of the steamer Seminole, I can, in justice, but come to the conclusion that Mr. Hawley, by his energy, coolness, and courage, saved the schooner from total destruction, as well as the brig Iza, mentioned in his report. Upon examining the schooner, I am only astonished that she was saved at all. The entire starboard quarter must have been in flames, besides the starboard rigging, and the deck on the quarter is completely charred. There was no wind, nor would the short interval which elapsed after the burning steamer had been drifted to the Peirce admit of getting the schooner under way and moving out of the reach of danger; hence, there was but one course left for him to pursue, and that one he followed, namely, to endeavor to tow the Seminole away from the schooner.

That the exertions of Mr. Hawley were not unattended with personal danger, you can judge from the fact that his clothing and hands were burned. I can but sorely regret so serious a casualty to the vessel under my charge, but, at the same time, a sense of justice obliges me to free Mr. Hawley from all cause of censure, and to give him the well-earned credit of having acted with judgment and courage; and I hope, sir, after these representations, you may be pleased to look upon it in the same light.

Respectfully submitted by your obedient servant,
A. M. HARRISON, *Assistant.*

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey, Washington, D. C.

UNITED STATES SCHOONER BENJAMIN PEIRCE,
Jacksonville, Florida, January 6, 1856.

SIR: The following is a report of the passage of the United States Coast Survey schooner Benjamin Peirce, from New York to Jacksonville, and also all the circumstances connected with her up to the time of your arrival at this place. We sailed from the Quarantine at New York on December 12th, standing down the bay with a light N.W. wind, and, by the time we had cleared Sandy Hook, the wind shifted directly ahead. It was snowing, and the weather became very thick; so much so, that, although we were some ten or twelve miles from Sandy Hook, we were obliged to put back and come to anchor just inside the Hook. It snowed all night and most of the next day, with the wind ahead, and blowing very strongly. The wind shifted about dark, and, getting under way, we stood out to sea again. We had a good run down as far as Cape Charles; but the wind coming out directly ahead again, we came to anchor about dark, just inside of Cape Henry light.

The next afternoon, with wind still ahead, we started down the coast, but did not make Hatteras light until the night of December 17th. On the morning of the 18th, at four o'clock, we lost sight of the light, but kept close into the land all the way down the coast, so that we saw a number of the lights. Our run from Cape Hatteras to the St. John's river was a very fine one, only fifty-six hours from light to light. We lay to off St. John's bar for a pilot two hours. After we arrived inside the bar the pilot left us, and I piloted the vessel myself up the river to Jacksonville, where we arrived between eight and nine o'clock. After the sails had been furled, and the decks cleared up, the men went below.

Just before twelve I heard the cry of "fire" on shore, which I found was caused by the burning of the steamer "Seminole." There being no wind at the time, I did not attempt to get the vessel from her anchorage, nor could I if I had desired to do so; within a few moments after the alarm was given, the steamer was ablaze from stem to stern, and, having been cut from her moorings to prevent the adjoining buildings and wharves from catching fire, she was drifting down the stream. By the time I could collect the men on deck, the burning wreck was within fifty yards of the "Peirce," heading directly athwart her bows. Leaving one-half of the men on the "Peirce," all prepared with buckets and axes to prevent, if possible, the steamer becoming entangled in the rigging of the "Peirce," I manned the largest boat and started for the steamer, which, by this time, was close aboard, made fast a tow line and commenced towing her. The steamer struck the vessel just abaft the starboard fore-chains, but, having got a little headway by towing, she did not, as I feared she might, become fastened to the rigging of the "Peirce." In the short space of time occupied in towing her past the "Peirce," the intense heat destroyed the foresail, mainsail, and main gaff-topsail; also the starboard main shrouds and main topmast back-stay, with some of the running rigging; most of her spars and both masts were much charred, and also the starboard bulwarks, galley, cabin quarter-house, and deck. A new boat belonging to Mr. Huger, which was lying on the deck, was also considerably damaged. The glass in the skylight of the cabin was broken by the excessive heat, and the taffrail crushed by the falling of the main boom, the topping lift which supported it being destroyed. From six to eight hundred dollars will, I think, put the vessel in as good condition as formerly. Seeing that the flames on the "Peirce" were all extinguished, I continued towing the steamer to keep her clear of a brig which was at anchor a short distance astern of us. After a severe struggle the steamer was towed clear of the brig, and I went on board of her to render what assistance might be required. The captain of the brig not being able to control his men, and being very much alarmed himself, turned the command of the vessel over to me; and I do not hesitate to say, that, with the assistance of our own men from the Peirce, we succeeded in saving the brig "Iza," with a full cargo, from being totally consumed. Since the fire I have had carpenters at work planing down the masts and spars of the Peirce, which were all charred to the depth of a quarter of an inch; also in making new dead-eyes, &c., a new taffrail, and a rudder for the boat, which was lost.

As the main shrouds were nearly burnt through, and knowing that it would endanger the safety of the mast if it came on to blow very heavily with a rough sea, I took the responsibility of ordering immediately such standing rigging as was necessary. I have not ordered either sails or running rigging.

Regretting sincerely this misfortune, and believing that I have done my entire duty, I trust that this report may meet with your approval.

Very respectfully,

P. R. HAWLEY.

A. M. Harrison, Esq.,
Assistant U. S. Coast Survey, Jacksonville, East Florida.

APPENDIX No. 72.

Correspondence with the Secretary of the Treasury relative to the necessity of transferring Coast Survey parties from the main land of Florida peninsula, in consequence of threatened Indian hostilities.

COAST SURVEY OFFICE, *January* 30, 1856.

SIR: In consequence of reports which have reached this office, I am induced respectfully to request that inquiry may be made of the honorable Secretary of War, in order to ascertain whether any information recently received at the War Department would lead to the supposition that Coast Survey parties employed near Cape Sable, and on the small keys between the South Florida main and the southern line of keys, are exposed to danger from Indian hostilities.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

TREASURY DEPARTMENT, *February* 7, 1856.

SIR: I am informed by the Secretary of War, under date of the 5th instant, that no intelligence has been received at that Department indicating the presence of Florida Indians in the immediate vicinity of Cape Sable; but from the character of the Indians, and from the fact that they are likely to approach the coast for supplies, it is considered that the continuance of the Coast Survey parties near Cape Sable may be attended with danger.

Very respectfully, your obedient servant,

JAMES GUTHRIE,
Secretary of the Treasury.

Prof. A. D. BACHE,
Superintendent of Coast Survey.

APPENDIX No. 73.

Correspondence with the Treasury and Navy Departments, and letter of Commander James Alden, U. S. N., assistant in the Coast Survey, on joining the Pacific squadron to engage in repelling Indian hostilities in Washington Territory.

COAST SURVEY OFFICE, *January* 2, 1856.

SIR: I believe you will be gratified, as I have been, to see the promptness with which Commander Alden volunteered the services of the Coast Survey steamer Active to go to the north, placing her under the direction of the commander of the squadron for service. I enclose you a copy of Commander Alden's letter to me, and of the orders which he received from Commodore Mervine.

I would respectfully suggest that a copy of this letter, and of its enclosure, be transmitted to the honorable Secretaries of War and of the Navy, that they may be aware of the co-operation thus afforded by the use of the Coast Survey steamer Active.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

U. S. COAST SURVEY STEAMER ACTIVE,
San Francisco, December 3, 1855.

DEAR SIR: The enclosed communication from Commodore Mervine will explain itself, and I trust my course in placing this vessel at his disposal will meet your approval. I hesitated to do so till the necessity of the case made my duty so apparent that I should have proved recreant to the call of humanity if I had remained passive. Independently of my knowledge of those localities which are so much exposed, I am satisfied that this vessel is more capable of affording aid and comfort to our citizens, by moving with celerity from one point to another, than two or three sloops of war, without the aid of steam, in such warfare. Our capacity, too, for towing vessels of that class which may be operating there, will be felt; for the transportation of troops and supplies, I think the Active can hardly be equalled by any vessel of her size. It is my intention to carry out these views, and I trust that, if action and energy will accomplish anything, you will never have cause to regret our participation in this affair. Commodore Mervine has done everything in the way of furnishing all the means and appliances in his power to stop this disastrous warfare, and has supplied this vessel with everything for the successful prosecution of so desirable an end.

I leave Lieutenant Cuyler in command of the Ewing, with sufficient force to carry on the hydrography of the bay, (the work laid out for the Active this winter,) and knowing well, as you do, his long experience and peculiar aptitude for the work, I need hardly add that I have the most sanguine expectations that he will produce many and highly satisfactory results. My instructions to him are also herewith enclosed; and you will perceive that, as my absence may be more or less protracted, I have directed him to communicate directly to you.

Before closing, I desire to record the high sense of obligation that I feel towards Lieutenant T. G. Corbin, U. S. N., the executive of the navy yard at Mare island, who has so promptly volunteered his services, and is now temporarily attached to this vessel as first lieutenant. Our preparations are almost completed, and we expect to leave here on to-morrow or next day.

With great respect, I remain, very truly, your obedient servant,

JAMES ALDEN,
Commander U. S. N., Assistant Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey, Washington, D. C.

UNITED STATES FLAG-SHIP INDEPENDENCE,
San Francisco, November 29, 1855.

SIR: The savage demonstrations of the Indians in Washington Territory, in murdering many of the settlers, the concert of action between the different tribes, together with their attacks upon the regular troops, seem to indicate a general Indian war, the declared object of which is the extermination of all the white population.

This alarming state of affairs calls for all the available naval force which can be spared from other duties.

As you have promptly tendered the services of the United States surveying steamer Active, under your command, which you state can be spared during the winter without detriment to the service in which she is engaged, you will therefore prepare her for sea with all possible despatch, and, so soon as you shall be ready, proceed to Puget's Sound, where you will act in concert with the sloop of war Decatur, and the forces under the command of Major General John E. Wool, in affording aid and protection to the inhabitants residing on the Sound, wherever the same may be required.

You will take on board as large a supply of stores, especially bread, as your vessel can stow. Upon falling in with the Decatur at Seattle, transfer to her all your surplus stores.

Commander Sterett reports that, in consequence of the settlers being without arms, he has supplied them with all those belonging to the Decatur; you will therefore make a requisition upon the ordnance officer of the United States army at Benicia for forty muskets, and the same number of pistols and cutlasses, if they can be furnished, for her use.

I shall, in all probability, sail from this port very soon; you will therefore communicate all matters of importance, through Commander Gansevoort, direct to the Honorable Secretary of the Navy, as circumstances shall render expedient, transmitting to me duplicate copies thereof, to Valparaiso, by the way of Panama, addressed to the care of the United States consul at the latter place.

Very respectfully, your obedient servant,

WM. MERVINE,
Commanding Pacific Squadron.

Commander James Alden,
U. S. Coast Survey Steamer Active.

Navy Department, *January* 5, 1856.

Sir: I have the honor to acknowledge the receipt of your communication of the 4th instant, enclosing copy of one to your address from the Superintendent of the Coast Survey, "expressive of his gratification at the promptness with which the services of the Coast Survey steamer Active were tendered by Commander Alden to Commodore Mervine to act under his direction, as commander of the Pacific squadron, to quell the Indian disturbances in Washington Territory; also, a copy of Commander Alden's letter to Professor Bache, and of the orders issued by Commodore Mervine on accepting the services of the Active.

I am extremely gratified with the zeal and energy of Commander Alden, and his promptness in placing his vessel at the disposal of Commodore Mervine. His course meets the hearty approval of the Department, and it is hoped it will not interfere materially with Coast Survey duties.

With very great respect, I am, sir, your obedient servant,

J. C. DOBBIN.

Hon. James Guthrie,
Secretary of the Treasury.

APPENDIX No. 74.

Letter to the Secretary of the Treasury, transmitting, for the files of the War Department, copy of a letter addressed to Capt. A. A. Gibson, U. S. A., on his detachment from Coast Survey service.

Coast Survey Office, *December* 21, 1855.

Sir: I have the honor to inform the Department that the direction to relieve Captain Gibson, U. S. A., assistant in the Coast Survey, from duty, and to request him to report to the Hon. Secretary of War, has been complied with. In justice to this useful officer, I enclose a copy of my remarks on relieving him, for the files of the Department, and would respectfully request that a copy thereof may be transmitted to the Hon. Secretary of War.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. James Guthrie,
Secretary of the Treasury.

COAST SURVEY OFFICE, *December* 21, 1855.

SIR: I have the honor to enclose a copy of a letter from the Treasury Department and its accompanying inclosure from the War Department, and, in accordance with the directions of the Secretary of the Treasury, to relieve you from duty on the Coast Survey, and to instruct you to report by letter to the Hon. Secretary of War.

In doing so, I must express the reluctance with which I part with one who has made himself so useful upon the Coast Survey. The sketches of parts of the coast have been made with consummate skill and a just appreciation of the purpose for which they were intended. The projects of maps and charts have been studied with great industry and attention, and an aptness rarely found. The correct taste in arrangement and execution which you possess, and which has with praiseworthy zeal been exercised in the Coast Survey office, deserves acknowledgment and such reward as praise may be considered to afford. I shall miss very much your varied talent in sketching in the field, in drawing in the office, and in connection with the drawing and engraving divisions of the office. In the study of the projects of maps and charts, your experience and information will also be very much missed and cannot soon be replaced.

I shall send a copy of this letter to the Hon. Secretary of the Treasury, and, through him, to the Hon. Secretary of War.

Very respectfully and truly yours,

A. D. BACHE, *Superintendent.*

Captain A. A. GIBSON, U. S. A.,
Assistant Coast Survey.

APPENDIX No. 75.

Communication to the Secretary of the Treasury, transmitting copy of a letter addressed to Captain W. R. Palmer, U. S. Topographical Engineers, on the occasion of his detachment from Coast Survey service.

COAST SURVEY OFFICE, *May* 21, 1856.

SIR: I have the honor to communicate to the Treasury Department, for its files, a copy of a letter addressed to Captain W. R. Palmer, U. S. Topographical Engineers, recently relieved from Coast Survey duty, and would respectfully request that a copy may be transmitted to the Hon. Secretary of War, for the files of the War Department.

The efficiency of Captain Palmer while engaged in the duties of the Coast Survey, in my judgment, merits this expression of the value of his services.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

COAST SURVEY OFFICE, *May* 21, 1856.

DEAR SIR: By direction of the Treasury Department, I communicate to you the orders of the War Department, referring to your detachment from the Coast Survey under the four years' rule.

I take this occasion to express my high sense of the value of your services to the Coast Survey, and the great regret with which I part with them. Your duty has invariably been discharged with zeal, efficiency, and ability, and with a scrupulous care worthy of the highest praise. The triangulation which you made of the Rappahannock river, in Virginia, is one of the best of its kind in the Coast Survey, and your services as assistant in charge of the Coast Survey office, in the absence of Captain Benham, have been highly acceptable. Having taken occasion to inspect the office soon after you took charge of it, and at the present time, I bear testimony to the success of your administration of it.

I propose to place this letter on file in the Treasury and War Departments. In parting with you, allow me to wish you continued success in your new field of service.

With great regard, yours, truly and respectfully,

A. D. BACHE, *Superintendent.*

Captain W. R. PALMER, *U. S. Top. Engrs.*,
Assistant in charge of Coast Survey Office, ad int.

APPENDIX No. 76.

Letter of the Secretary of the Treasury, notifying of the detachment for special service of Lieut. Comg. O. H. Berryman, U. S. N., Assistant Coast Survey, and Midshipman John S. Barnes.

TREASURY DEPARTMENT, *June* 24, 1856.

SIR: The Secretary of the Navy has notified the Department, under date of the 23d instant, that, in consequence of the services of Lieutenant O. H. Berryman* and Midshipman John L. Barnes being immediately required on special duty, under the act of Congress of 3d March, 1849, these officers have been detached from Coast Survey duty, and that their places will be at once supplied, upon a requisition from your office.

Very respectfully, your obedient servant,

JAMES GUTHRIE,
Secretary of the Treasury.

Prof. A. D. BACHE,
Superintendent Coast Survey, Washington, D. C.

CHAP. CIII.—An act making appropriations for the Naval service for the year ending June 30, 1850.

*   *   *   *   *

SEC. 2. *And be it further enacted,* That the Secretary of the Navy be directed to detail three suitable vessels of the navy, in testing new routes and perfecting the discoveries made by Lieutenant Maury in the course of his investigations of the winds and currents of the ocean, and to cause the vessels of the navy to co-operate in procuring materials for such investigations, in so far as said co-operation may not be incompatible with the public interests: *Provided,* That the same can be accomplished without any additional expense.

*   *   *   *   *

Approved March 3, 1849.

APPENDIX No. 77.

Correspondence with Lieutenant Colonel R. E. De Russy, United States Engineers, in reference to the engagement of Lieutenant N. F. Alexander for the continuance of tidal observations on the Western Coast.

COAST SURVEY OFFICE, *March* 1, 1856.

DEAR COLONEL: I understand from General Totten that he will write to you, authorizing—if, in your judgment, it will not interfere with the performance of engineer duties—the engagement

* Since reassigned.

of Lieutenant N. F. Alexander in the supervision of tidal observations at three stations already established on the Western Coast.

Lieutenant Trowbridge will, at my request, call and explain to you the nature of the service desired of Lieutenant Alexander. It is my intention that it *shall not* interfere; so that if, in practice, any interruption of regular duty is likely to occur in any part, I will make a change at once in my request to Lieutenant Alexander, on learning that it is desired by you.

Yours, respectfully,

A. D. BACHE, *Superintendent.*

Col. R. E. De Russy, *United States Engineers.*

San Francisco, California, *April* 4, 1856.

My Dear Sir: Your letter of the 1st of March was handed to me by Lieutenant Trowbridge; I had previously received General Totten's letter on the same subject.

I found my assistant, Lieutenant Alexander, willing and ready to relieve Lieutenant Trowbridge in the supervision of the tidal observations at the stations already established on the Western Coast, and I did not hesitate to accede to your request, although much pressed for time and assistance. I need not add, that in common with the officers of the corps, I feel that we owe much to your department for valuable information and useful assistance, and that I will always be happy to lend my aid in the performance of services which can in any way reciprocate the kind feelings which I trust will always exist between the two departments.

With great respect and esteem, I am, my dear sir,

R. E. DE RUSSY,
Lieutenant Colonel Engineers.

Prof. A. D. Bache,
Superintendent U. S. Coast Survey, Washington, D. C.

Coast Survey Office, *Washington, May* 6, 1856.

Dear Colonel: On my return from the south I received your very kind letter of April 4th, and beg at once to return my thanks for the promptness of your action in reference to the matter. I appreciate fully all that you say in regard to the pressure already existing upon the time and talents of your assistant, Lieutenant Alexander, and value accordingly the aid which you and he have consented to render in regard to the tidal observations on the Western Coast.

Reciprocating entirely your expressions of kind feeling, and sincerely thanking you for those relating to the Coast Survey,

I remain, very respectfully and truly yours,

A. D. BACHE, *Superintendent.*

Lieutenant Colonel De Russy, *Corps of Engineers.*

APPENDIX No. 78.

Aids to navigation recommended in reports made to the Superintendent by assistants in the Coast Survey.

Section.	Object.	By whom recommended.	Date of report, &c.
I.	Buoys at entrance to the Kennebec river	Lieut. Comg. S. D. Trenchard, U. S. N.	Referred to Light-house Board October 15, 1856.
I.	Buoys on rock near Half-way rock, Casco bay	Lieut. Comg. S. D. Trenchard, U. S. N.	Referred to Light-house Board October 1, 1856. (*Appendix No.* 9.)
I.	Buoy on *Stellwagen's reef*, between Minot's light and Scituate light.	Commander H. S. Stellwagen, U. S. N.	September 26, 1856. (*Appendix No.* 10.)
I.	Buoys on ridges fifteen miles eastward of Sankaty Head light	Commander H. S. Stellwagen, U. S. N.	Referred to Light-house Board August 16, 1856. (*Appendix Nos.* 11, 79.)
I.	Buoy on Edwards' shoal, near southern Cross Rip	Lieut. Comg. C. R. P. Rodgers, U. S. N.	Referred to Light-house Board December 8, 1856. (*Appendix No.* 12.)
V.	Buoys for channel ways, Port Royal entrance	Lieut. Comg. J. N. Maffitt, U. S. N.	(*Appendix No.* 15.)
V.	Designation of buoys on Atlantic coast south of Savannah	Lieut. Comg. T. A. Craven, U. S. N.	Referred to Light-house Board April 21, 1856. (*Appendix No.* 80.)
V.	Buoy on shoal eastward of St. Simon's bar, Georgia	Lieut. Comg. S. D. Trenchard, U. S. N.	Referred to Light-house Board July 26, 1856. (*Appendix No.* 81.)
VI.	Buoy on reef between Cape Florida light-house and Fowey rocks.	Lieut. Comg. T. A. Craven, U. S. N.	Referred to Light-house Board September 20, 1856. (*Appendix No.* 82.)

APPENDIX No. 79.

Letter of the Superintendent, communicating the recommendation of Commander H. S. Stellwagen, U. S. N., assistant in the Coast Survey, for placing buoys on shoal spots found eastward of Sankaty light-house.

COAST SURVEY OFFICE, *August* 16, 1856.

DEAR SIR: In a letter received to-day from Commander H. S. Stellwagen, U. S. N., assistant in the Coast Survey, he recommends the placing of a large buoy on a narrow ridge E. 3° N. (true) from Sankaty Head, fifteen miles and a half distant, and one on a sixteen feet spot, two miles north of this. He also states that no time should be lost in placing these buoys. The positions are marked on the accompanying proof.

Yours, respectfully,

A. D. BACHE, *Superintendent.*

Commander T. A. JENKINS, U. S. N.,
Secretary Light-house Board.

APPENDIX No. 80.

Letter to the Secretary of the Treasury, transmitting the recommendation of Lieut. Comg. T. A. Craven, U. S. N., assistant in the Coast Survey, for designating the buoys on the Atlantic coast, southward of Savannah river entrance.

SAVANNAH, GEORGIA, *April* 21, 1856.

SIR: I have the honor to communicate to the Department an extract from a letter recently received from Lieut. Comg. T. A. Craven, U. S. N., assistant in the Coast Survey, suggesting such practicable modification in the designation of buoys along the Atlantic coast southward of Savannah as would seem to add to their value as aids to navigation.

"In the frequent fogs of winter, navigators are in the habit of running in by the lead and searching for the outer buoys, which, however, are not distinguished one from the other. I would suggest, therefore, that all the prominent buoys from Savannah south be distinctly marked with the name of the place. I have often, in running down the coast, approached near enough to the buoys in question to distinguish the rivet heads without being able to see the land."

Being of opinion that the general object referred to by Lieut. Comg. Craven is an important one, I would respectfully request that a copy of this communication may be transmitted to the Light-house Board.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

APPENDIX No. 81.

Letter from the Secretary of the Treasury, transmitting the recommendation of Lieut. Comg. Stephen D. Trenchard, U. S. N., assistant in the Coast Survey, for placing buoys on the shoal eastward of St. Simon's bar, Ga., and on the south breaker.

BANGOR, MAINE, *July* 26, 1856.

SIR: I have the honor to append, for the information of the Light-house Board, the following extract from a report made under date June 18, by Lieut. Comg. S. D. Trenchard, U. S. N., assistant in the Coast Survey, having in charge the execution of hydrographic work on the coast of Georgia.

"About two miles to the eastward of the light-house (St. Simon's bar, Georgia) there is a narrow shoal running east and west with fifteen feet upon it at mean low water. The shoal has an area of four or five hundred square yards, with a channel upon either side of it. A buoy should be placed on the shoal, and one also upon the outer point of the south breaker."

I would respectfully request that a copy of this communication may be transmitted to the Light-house Board.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

APPENDIX No. 82.

Letter to the Secretary of the Treasury, transmitting the recommendation of Lieut. Comg. T. A. Craven, U. S. N., assistant in the Coast Survey, for a buoy on the reef between Cape Florida light-house and Fowey rocks.

UNITED STATES COAST SURVEY STATION,
Near Ellsworth, Me., September 20, 1856.

SIR: I have the honor to transmit herewith an extract from a letter of Lieut. Comg. T. A. Craven, U. S. N., assistant in the Coast Survey, recommending the placing of a buoy in the channel over the reef between Cape Florida light-house and Fowey rocks, and would respectfully request that it be forwarded to the Light-house Board.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

[EXTRACT.]

COAST SURVEY STEAMER CORWIN,
Harlem river, September 16, 1856.

DEAR SIR: * * * * * * * * * *

If I have not previously recommended it, I now advise placing a buoy in the channel over the reef between Cape Florida light-house and Fowey rocks. The anchorage inside of the rocks is an excellent harbor of refuge, which has often been resorted to by those acquainted with it.

Respectfully, your obedient servant,

T. AUG. CRAVEN,
Lieut. Comg. U. S. N., Assistant Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

APPENDIX No. 83.

Results of examinations for sites of light-houses, beacons, buoys, &c., made by the Coast Survey at the request of the Light-house Board, under directions from the Secretary of the Treasury, and in accordance with laws of March 3, 1851, *August* 31, 1852, *and August* 3, 1854.

Section.	Locality.	Object.	By whom examined.	Report of Superintendent.
II.	Bowers' beach, western sidé of Delaware bay.	Re-examination for light-house site..	Lieut. Comg. C. R. P. Rodgers, U. S. N.	Reported June 30, 1856. (*Appendix No.* 84.)
II.	Mouth of Old Duck creek, western shore of Delaware bay.	Re-examination for light-house site..	Lieut. Comg. C. R. P. Rodgers, U. S. N.	Reported June 30, 1856. (*Appendix No.* 84.)
VII.	St. Andrew's bay, western coast of Florida	General examination for aids to navigation.	Lieut. Comg. O. H. Berryman, U. S. N.	Aids recommended March 26, 1856. (*Appendix No.* 85.)
X.	Sand-spit, southeast of San Buenaventura, Santa Barbara channel.	Re-examination for light-house site..	Lieut. Comg. Archibald MacRae, U. S. N.	Recommended December 22, 1855. (*Appendix No.* 86.)
	Do...........do...............	......do..............do.........	Commander James Alden, U. S. N.....	Reported February 14, 1857.

APPENDIX No. 84.

Letter to the Secretary of the Treasury, communicating results of re-examinations made by Lieut. Comg. C. R. P. Rodgers, U. S. N., assistant in the Coast Survey, with reference to the expediency of establishing lights at Bowers' beach, and the mouth of Old Duck creek, Delaware bay.

NEW YORK, *June* 30, 1856.

SIR: In pursuance of the request of the Light-house Board, I have had a re-examination made in reference to the question of light-houses at Bowers' beach and Old Duck creek, in Delaware, and have the honor to enclose a copy of the report relating thereto, of Lieut. Comg. C. R. P. Rodgers, U. S. Navy, Assistant Coast Survey.

I concur in the conclusions stated by Lieut. Comg. Rodgers.

Yours respectfully,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

UNITED STATES SCHOONER GALLATIN,
New York, June 9, 1856.

SIR: I have executed your instructions which directed me to make an examination for the selection of sites for light-houses at Bowers' beach and Old Duck creek, in Delaware bay.

At Philadelphia I obtained valuable information from the Collector of the Customs, from the chairman of the Board of Trade, committee on the navigation of Delaware Bay, and from the Light-house Inspector for the district.

From Philadelphia I went to Old Duck creek, whose waters enter the bay at three points; at Smyrna creek or the Thoroughfare, where there is already a light-house; at Leipsic creek, of which I shall speak hereafter; and at the mouth of Dona river, where its channel is no longer navigable by even the smallest vessels. Dona river has no trade whatever, but is sometimes visited by small vessels seeking shelter in bad weather. There is, however, a more generally frequented port of refuge at Mahon's river, which possesses an excellent light, and is only three miles distant from the mouth of the Dona.

I am well satisfied, by abundant evidence, that Congress granted the late appropriation for a light-house at or near the mouth of Old Duck creek, in compliance with the petition of citizens of the town of Leipsic and its vicinity, which was presented and urged in their behalf by the representative from Delaware. Through that mouth of Old Duck creek, now called Leipsic creek, passes the trade with Leipsic and its neighborhood; transient vessels occasionally visit that town, and its citizens own eight small schooners, constantly engaged in carrying freight. To these vessels a light-house at Leipsic creek will undoubtedly prove convenient; but they now enter that stream by night, as well as by day, without any such aid, guided by their leads and by the excellent lights at Bombay Hook, Cohansey, and Mahon's river.

Should it be deemed advisible to build a light-house at or near the mouth of Old Duck creek, I respectfully recommend that it be placed on Kent island, sixty yards from Leipsic creek, with the tavern at Dona landing, bearing, *by compass*, S. 45° 30′ W., and the Lower Thrum Cap N. 19° W. At this point I have driven stakes to mark the proposed site, and I have made its precise position known to the Light-house Inspector for the district.

Bowers' beach is about three quarters of a mile long, and lies between the mouths of Jones' and Murderkill creeks, which are very nearly dry at low water. I am informed that much valuable produce is sent from the banks of these creeks in small vessels of light draught; to these small craft a light-house would be of service, by marking with precision the position of Bowers' beach, and might be of use should they attempt to enter the creeks at night.

Should a light-house be built on Bowers' beach, I respectfully recommend that it be placed about forty-five yards from high water mark, near the tavern, and to the southward and eastward of it, in the cultivated field adjoining the road on which the tavern stands. This site will be about six and three-quarter miles from the light-house at Mahon's river, and about nine and a quarter from that at Mispillion.

In conclusion, I beg leave to state my opinion that these proposed lights, though they might be useful to the small vessels navigating the creeks in their vicinity, would be of little or no service to the general navigation of Delaware bay, and I cannot perceive that any exigency exists which requires their erection.

No general system of lighting our coast can be rendered so comprehensive as to afford light-houses to every locality possessing a small trade in vessels of light draught.

I am not aware that any other improvement to facilitate the entrance of the creeks referred to is either needed or asked for.

I have the honor to be, respectfully, your obedient servant,

C. R. P. RODGERS,
Lieut. U. S. N., Assistant U. S. Coast Survey.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey, Washington.

APPENDIX No. 85.

Letter to the Secretary of the Treasury, transmitting a communication from Lieut. Comg. O. H Berryman, U. S. N., assistant in the Coast Survey, with recommendations for aids to navigation in St. Andrew's bay, Florida.

TREASURY DEPARTMENT, OFFICE LIGHT-HOUSE BOARD,
January 3, 1856.

SIR: Application having been made to this office, by the Secretary of the Treasury, for information touching the necessity for aids to navigation in St. Andrew's bay, Florida, I have respectfully to request to be furnished with any data which you may have and which it will be proper to communicate to assist in answering the call.

Very respectfully, your obedient servant,

T. A. JENKINS, *Secretary.*

Professor A. D. BACHE,
Superintendent of Coast Survey, Washington, D. C.

COAST SURVEY OFFICE, *March* 26, 1856.

SIR: The request of the Light-house Board for information relative to aids to navigation desirable in the vicinity of St. Andrew's bay, Florida, as stated in your letter of January 3, was referred, without delay, to the officer charged with the execution of the hydrography of that section.

I have now the honor to enclose a copy of the letter of Lieut. Comg. Berryman in reply to the call for information, and would much regret if inconvenience should have been occasioned at the Light-house Board in consequence of the late receipt, by Lieut. Berryman, of the communication which for better security was addressed to him in duplicate.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Commander T. A. JENKINS,
Secretary Light-house Board.

U. S. SCHOONER VARINA, ST. MARK'S RIVER, FLORIDA,
March 14, 1856.

SIR: Your letter of the 8th January, enclosing a copy of one from the Secretary of the Light-house Board, requesting information relative to any aids which it may be deemed expedient to establish at St. Andrew's bay, Florida, I did not receive until to-day.

In answer to those inquiries, I have the honor to state that the commerce of St. Andrew's bay is very small and that it is confined almost entirely to lumber, tar, and turpentine.

The bay is an excellent resort for vessels of small draught of water for shelter, and a light-house and buoys would greatly facilitate their entering across the bar at night, which cannot now be attempted without great danger, if at all.

A light-house may be conveniently placed at a point to enable vessels to steer in over the bar and get into good anchorage *on one course,* either *N. by W.* or *N.N.W.* Two buoys on the bar and one inside between the breakers would be useful, and others placed so as to lead vessels over the deepest part of a long sand bar, which obstructs the further entrance to this fine bay, are indispensable, as there are no pilots to be had. Two posts, such as are placed on the edges of the channel of this river (St. Mark's,) would be advisable to mark the passage across this sand bar, where thirteen feet may be found at full tides. All the other parts of the channels to the saw-mills and St. Andrew's city are very deep, and a few stakes or buoys would be quite sufficient for present purposes.

I am, very respectfully, your obedient servant,

O. H. BERRYMAN,
Lieut. Comg. U. S. N., and Assistant Coast Survey.

Professor A. D. BACHE,
Superintendent Coast Survey, Washington, D. C.

APPENDIX No. 86.

Letter to the Secretary of the Treasury, transmitting copy of report made by Lieut. Comg. Arch'd MacRae, U. S. N., assistant in the Coast Survey, upon concluding his examination of Santa Cruz and Anacapa islands, California, and of the adjacent main for a light-house site.

COAST SURVEY OFFICE, *December* 22, 1855.

SIR: Under date of October 11, 1855, I had the honor to report, in part, in relation to the examination of Santa Cruz and Anacapa islands, off the Santa Barbara channel, California, for light-house purposes, stating that a further examination was directed and was in progress, before a final report should be made.

I have now the honor to recommend as a site for a sea-coast light in this vicinity, a point twelve to fifteen miles S.E. of San Buenaventura. The reasons given for establishing this light, by Lieut. Comg. Archibald MacRae, U. S. N., assistant in the Coast Survey, are fully stated in his report, a copy of which is now enclosed. The coast of the main has been carefully examined by him, as well as the islands lying off it, and he renews his previous report against the placing of a light on the island of Anacapa or on the east end of Santa Cruz.

I would call attention to the remarks of Lieut. Comg. MacRae in regard to the height of the light above the sea, and would request that a copy of this letter may be forwarded with a copy of the enclosed report of Lieut. Comg. MacRae to the Light-house Board.

Very respectfully, yours,

A. D. BACHE, *Superintendent.*

Hon. JAMES GUTHRIE,
Secretary of the Treasury.

U. S. SURVEYING SCHOONER EWING,
Off Santa Barbara, California, November 5, 1855.

SIR: As we have now concluded work in the Santa Barbara channel for this season, I beg leave to make the following report with regard to a proper light-house site.

If the object of establishing a light-house be to guide vessels from the southern coast, a light on the south end of San Nicolas or of San Clemente would be preferable to either Santa Cruz or "Anacapa," but the rock on "Cortez Shoal" makes it imprudent for vessels to attempt that passage. If they go to the eastward, I think the light on Point Loma will be sufficient; if to the westward, and another light be determined on for that special purpose, the east end of San Miguel appears to have the preference. Should, however, the object of the light be to guide vessels channel bound, I think there can be no doubt that a sand-spit about twelve or fifteen miles S.E. of San Buenaventura is the best, if not the only place for any light beyond those already determined on. From San Buenaventura, for about three miles, there is a sand beach backed by low cliffs, the high hills receding to the northward and eastward. Thence the cliffs cease, and a low sand beach partially wooded and backed by hillocks, very much resembling the coast of North Carolina, extends for about twelve miles. In this beach line there are three lights separated by sand-pits, the second one of which makes out furthest to the southward, and is, I think, the place for a light, for three reasons: First, that a direct course from Point Vincent, near San Pedro, to Santa Barbara cuts the edge of the point; second, because the high land back is remote; and third, because the approach to it, although shelving and gradual to the westward, is steep and abrupt to the eastward.

I have already, under date of July 27, given my reasons for thinking a light unnecessary on either "Anacapa" or the east end of Santa Cruz. Since then we have passed between Santa Rosa and the west end of Santa Cruz, and I can see no reason for a light there, or for changing my former opinion. Indeed, I believe that all vessels except coasters make the passage, north or south, outside of the islands.

With regard to the class of light, I think it should be strong but placed low down, say forty feet, for the reason that the haze frequently settles down at night obscuring everything above, but leaving a line of coast visible below. Mr. Stone, sailing master, Mr. P. C. Johnson, passed midshipman from the Active, temporarily attached, and Mr. E. A. King, watch officer, concur with me in the foregoing opinion.

* * * * * * * * * * *

I have the honor to be, very respectfully, your obedient servant,

ARCH'D MACRAE,
Lieut. Comg. U. S. N.

Commander JAMES ALDEN,
Chief of hydrographic party W. Coast of the U. S., San Francisco, Cal.

INDEX TO SKETCHES AND DIAGRAMS.

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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This project currently includes the imaging of the full text of each volume up to the "List of Sketches" (maps) at the end. Future online links, by the National Ocean Service, located on the Historical Map and Chart Project webpage (http://historicals.ncd.noaa.gov/historicals/histmap.asp) will includes these images.

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